Volume 22, Number 2, January 31, 1968

NUCLEAR SCIENCE ABSTRACTS

A semimonthly publication of the USAEC Division of Technical Information, Edward J. Brunenkant, Director, Published by the USAEC Divison of Technical Information Extension, Robert L. Shannon, Extension Manager.

Nuclear Science Abstracts provides the only comprehensive abstracting and indexing coverage of the international literature on nuclear science and technology. *NSA* covers scientific and technical reports of the U. S. Atomic Energy Commission and its contractors, those of other U. S. Government agencies, and those of other governments, universities, industrial, and research organizations. It also covers patents, books, and journal literature on a worldwide basis.

Scanning, selecting, and abstracting the literature in Canada, Denmark, Finland, Japan, Norway, Sweden, and the United Kingdom are carried out by the following organizations:

Atomic Energy of Canada Limited
Danish Atomic Energy Commission
Finnish Atomic Energy Commission
Japan Atomic Energy Bureau–Atomic Energy Research Institute
Institutt for Atomenergi (Norway)
Aktiebolaget Atomenergi (Sweden)
United Kingdom Atomic Energy Authority

Through special cooperation of the Netherlands Patent Office and the Institut International des Brevets, abstracts of European patents are provided. Numerous organizations, societies, and publishers throughout the world provide advance page-proof copy of their journals and publications. In the United States page-proof copy of the publications of the American Institute of Physics is provided.

A list of the journals regularly scanned appears in Issue Number 1. This list is supplemented in each odd-numbered issue. Nearly 450,000 abstracts have appeared in *NSA* through Volume 21. The subject matter covered in *NSA* is described in Issue 1 of each volume and in TID-4552, *Subject Scope of Nuclear Science Abstracts*. The latter is available free from the U. S. Atomic Energy Commission, Division of Technical Information Extension, P. O. Box 62, Oak Ridge, Tennessee 37830.

Abstracts are arranged according to subject categories which are defined in Issue 1 of each volume. If the language of the original item is not English, the language is indicated.

AVAILABILITY OF PUBLICATIONS ABSTRACTED

The public availability of all U. S. Atomic Energy Commission reports is indicated in the report number indexes. The availability of other reports, when known, is also indicated. The availability of some unnumbered reports is given in the abstract.

Dissertations abstracted in *Dissertation Abstracts* and included in *NSA* are available from University Microfilms, Inc., 315 N. First Street, Ann Arbor, Michigan 48103.

Information on the availability of the published literature and unpublished conference papers abstracted in *NSA* may be obtained from the Division of Technical Information Extension, P. O. Box 62, Oak Ridge, Tennessee 37830.

HOW TO OBTAIN NUCLEAR SCIENCE ABSTRACTS

NSA is available to the general public on a subscription basis from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402, as follows:

For the 24 regular issues, $30.00 domestic, $37.00 foreign. A single issue costs $1.75, plus 25 percent for foreign mailing. Domestic rates apply to the United States, Canada, Mexico, and Central and South American countries except Argentina, Brazil, Guyana, French Guiana, Surinam, and British Honduras. Foreign rates apply to the countries excepted above and to all other countries throughout the world.

For the quarterly, semiannual, and annual indexes, $22.00 domestic, $25.00 foreign.

Multivolume indexes are available as follows:

From Johnson Reprint Corporation, 111 Fifth Avenue, New York, N. Y. 10003

Vols. 1–4, Subjects and Authors (1948–1950). $30.00

From Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402

Vols. 5–10, Subjects and Authors (1951–1956). $5.25
Vols. 11–15, Subjects (1957–1961). $19.00
Vols. 11–15, Personal Authors (1957–1961). $14.25
Vols. 11–15, Corporate Authors (1957–1961). $2.50
Vols. 16–20, Subjects (1962–1966). $36.00
Vols. 16–20, Personal Authors (1962–1966). $22.50
Vols. 16–20, Corporate Authors (1962–1966). $3.75
Cumulative Report Number Index, Vols. 1–15 Revised. $4.00
Cumulative Report Number Index, Vols. 16–20. $4.25

NSA is available on an exchange basis to universities, research institutions, industrial firms, and publishers of scientific information. Inquiries should be directed to the U. S. Atomic Energy Commission, Division of Technical Information Extension, P. O. Box 62, Oak Ridge, Tennessee 37830.

Government agencies may obtain *NSA* free of charge.

INDEXES TO NSA

Comprehensive indexes appear in each issue and are cumulated quarterly, semiannually, and annually. Multivolume cumulations have been issued as indicated above.

All documents abstracted are indexed by subjects and personal authors. Technical report literature is indexed also by corporate author and report number. Each of these indexes in every issue is preceded by an introduction explaining in detail the organization of the index and the principles by which it is compiled. The reader is referred to these explanations for information not found in the brief summary below.

Index References

All index entries refer the reader to volume and abstract number:

```
FOURRIER, Alain
  Radioactive chain of mass number 189,  21:10023
```

Personal Authors

Every author's name is indexed in the form appearing on the document abstracted:

```
MONTH, M.
  Theory of gradient perturbations in AGS,  21:9872 (BNL-
    10899)
MONTH, Melvin
  Simple relativistic calculation of the electromagnetic
    form factors of the deuteron,  21:9744
```

Subjects

The subject index consisting of specific materials, objects, and processes is arranged alphabetically. Modifying phrases specific to these subjects in turn are arranged alphabetically under the subjects.

```
SHEEP
  radiation dosimetry in, measurement of lethal dose of x,
    21:8905(R) (AD-631189)
  radiosensitivity of hematopoietic system of, x,
    21:8905(R) (AD-631189)
```

```
SHELTERS
  construction of, for civil defense,  21:8838
  design of fallout,  21:8777(R) (AD-629736)
  design of shaft closure for,  21:8563(P)
  determination of configuration of, for ventilation,
    21:8779(R) (AD-629928)
  equipment for fallout, minimal requirements of,
    21:8782(R) (AD-631424)
  evaluation of fallout, for fire and air blast damage,
    21:8560 (URS-658-3)
  fire resistance of components of, evaluation of,
    21:8789(R) (AD-642241)
```

Corporate Authors

Technical report literature is indexed from the name of the organization or institution responsible for the issuance of the report.

8500 (Y-1561) MIXING AND SAMPLING ENRICHED ^{235}U FLUIDS IN CYLINDRICAL STORAGE CONTAINERS. Final Report. Harrell, J. E. **(Union Carbide Corp., Oak Ridge, Tenn. Y-12 Plant).** Jan. 17, 1967. Contract W-7405-eng-26. 124p. Dep. mn. CFSTI $3.00 cy, $0.65 mn.

is indexed as:

```
UNION CARBIDE CORP., OAK RIDGE, TENN.  Y-12 PLANT.
  Mixing and sampling enriched 235U fluids in cylindrical
    storage containers,  21:8500 (Y-1561)
```

Report Numbers

Technical report literature is also indexed by report numbers. This index includes information on where individual reports may be obtained. While not reports, patents and conference papers are indexed here as a matter of convenience.

```
TID-
  3311(Suppl.  21-8567   Dep. mn. CFSTI $3.00 cy, $0.65 mn
    2)
  22298        21-9915   Nucl. News, 9: No. 12, 17-21 (Dec.
                           1966)
  22298        21-9914   Nucl. News, 10: No. 1, 17-20(Jan.
                           1967)
  23267        21-9702   Phys. Rev., 152: 1171-82(Dec. 23,
                           1966)
  23287        21-8498   Dep. mn. CFSTI $3.00 cy, $0.65 mn
  23420        21-8764   Lancet, 2: 672-5(Sept. 24, 1966)
  23474        21-8528   Dep. mn. CFSTI $3.00 cy, $0.65 mn
  23478        21-8641   Dep. mn. CFSTI $3.00 cy, $0.65 mn
  23482        21-9471   Dep. mn. CFSTI $3.00 cy, $0.65 mn
```

TABLE OF CONTENTS

Volume 22, Number 2, January 31, 1968

Category	Page
CHEMISTRY	199
Analytical Chemistry	199
Inorganic, Organic, and Physical Chemistry	205
Radiation and Nuclear Chemistry	213
Radiochemistry	221
Separation Processes	221
EARTH SCIENCES	224
Geology and Hydrology	224
Meteorology	226
Mineralogy and Exploration	229
Oceanography	229
Seismology	229
ENGINEERING	230
Nuclear Explosions	230
Facilities and Equipment	230
Heat Transfer and Fluid Flow	233
Isotope Technology	234
Materials Testing	235
Radioactive Material Handling	236
Vacuum Engineering	238
INSTRUMENTATION	239
Radiation Detection Instruments	239
General Detectors and Monitors	239
Nuclear Spectroscopic Instrumentation	243
High Energy Physics Instrumentation	246
Radiation Dosimeters	247
Radiometric Instruments	248
Miscellaneous Instruments and Components	248
Radiation Effects on Instruments and Instrument Components	251
LIFE SCIENCES	252
Biochemistry, Physiology, and Molecular Biology	252
Ecology	253
Genetics and Cytogenetics	253
Health Physics and Safety	254
Medicine	257
Radiation Effects on Animals	258
Radiation Effects on Plants	262
Radiation Effects on Microorganisms	262
Radiosterilization and Radiopreservation	262
METALS, CERAMICS, AND OTHER MATERIALS	263
Metals and Alloys	263
Corrosion and Erosion	263
Preparation and Fabrication	266
Properties Evaluations	268
Structure and Phase Studies	272
Radiation Effects	273
Ceramics and Cermets	275
Corrosion and Erosion	275
Preparation and Fabrication	275
Properties Evaluations	276
Structure and Phase Studies	278
Radiation Effects	278
Plastics and Other Materials	279
PHYSICS (GENERAL)	280
Astrophysics and Cosmology	280
Atomic and Molecular Physics	286
Cosmic Radiation	290
Direct Energy Conversion	297

Category	Page
PHYSICS (GENERAL) *cont'd.*	
Fluid Physics	298
Geophysics	301
Low-Temperature Physics	307
Plasma and Thermonuclear Physics	310
Confinement and Heating of Plasma	310
Diagnostics of Plasma	312
Kinetics of Plasma	315
Production of Plasma	325
Stability of Plasma	325
Shielding	327
Solid-State Physics	328
Theoretical Physics	335
PHYSICS (HIGH ENERGY)	337
Particle Interactions and Properties (Experimental)	337
Electromagnetic	337
Weak	338
Strong (Baryon-Induced)	339
Strong (Meson-Induced)	340
Particle Interactions and Properties (Theoretical)	343
General	343
Electromagnetic	344
Weak	347
Strong (General)	349
Strong (Baryon No. = 0)	350
Strong (Baryon No. = 1)	352
Strong (Baryon No. ≥ 2)	357
Particle Invarance Principles and Symmetries	359
General	359
Applications (Electromagnetic and Weak)	360
Applications (Strong)	361
Field Theories	363
Quantum Field Theory	363
Gravitation and General Relativity	364
Scattering Theory	366
Particle Accelerators	368
PHYSICS (NUCLEAR)	371
Neutron Interactions with Matter	371
Nuclear Properties and Reactions, A ≤ 5	372
Nuclear Properties and Reactions, 6 ≤ A ≤ 19	373
Nuclear Properties and Reactions, 20 ≤ A ≤ 89	376
Nuclear Properties and Reactions, A ≥ 90	381
Nuclear Theory	387
REACTOR TECHNOLOGY	393
Central Power Reactors	393
Marine and Portable Power Reactors	400
Rocket and Space Reactors	400
Research and Test Reactors and Critical Assemblies	401
Production Reactors	404
Reactor Theory, Components, Fuels, and Accessories	404
GENERAL	409
CORPORATE AUTHOR INDEX	INDEX-1
PERSONAL AUTHOR INDEX	INDEX-9
SUBJECT INDEX	INDEX-63
REPORT NUMBER INDEX	INDEX-151

STAFF OF NUCLEAR SCIENCE ABSTRACTS

John W. Norris
Managing Editor

Donald D. Davis
Assistant Managing Editor

David E. Bost
Production Manager

Robert E. Upchurch
Subject Heading Specialist

J. Paul Meredith
Descriptive Cataloging Specialist

Joel S. O'Connor
Computer Index Coordinator

Clara L. Fox
Corporate Author Specialist

Mary H. Newman
Reports Evaluator

Section Editors

Everett J. Hoffman
Chemistry

Robert C. Kelly
Engineering; Earth Sciences; Metals and Ceramics

Lee M. Thompson
General Physics

Charles E. Stuber
High Energy Physics; Instruments

Helen G. Donald
Life Sciences

Lawrence T. Whitehead
Nuclear Data

James M. Jacobs
Reactor Technology

Abstractors

F. S. Armstrong*
Ellis R. Bedford
Mary M. Brown
Jane G. Buchanan
D. Lamar Cason
Perry G. Cotter
David C. Cunningham
Bennie G. Di Bona
Helen G. Donald
James R. Dulaney
Mary C. Grissom
Phyllis C. Hansen
Carolyn D. Houston
Rose V. Jermain
W. Hugh Kinser, Jr.
Sidney F. Lanier
Lisbeth C. Lieberman
Betty L. McDowell
William D. Matheny
John H. Mitchell
Dora H. Moneyhun
Jean F. Peckham
Henry D. Raleigh
Mona H. Raridon
Julia S. Redford
Francis L. Sachs
Billie H. Slatten
Lila B. Smith
Myrna L. Steele
Polly C. Summers
Anne G. Ward
Helen L. Ward
David C. West
Milton O. Whitson
Juanita Wilson

*Atomic Energy of Canada, Ltd.

Communication concerning the editorial policy and content of *NSA* should be addressed to the Managing Editor, *Nuclear Science Abstracts*, AEC Division of Technical Information Extension, P. O. Box 62, Oak Ridge, Tennessee 37830.

Use of funds for printing this publication approved by the Director of the Bureau of the Budget, June 28, 1966.

Volume 22, Number 2 January 31, 1968

NUCLEAR SCIENCE ABSTRACTS

CHEMISTRY

Analytical Chemistry

Refer also to abstracts 2347, 2575, 2715, and 3697.

1944 (AE-296) INVESTIGATION OF TRACE ELEMENTS IN MARINE AND LACUSTRINE DEPOSITS BY MEANS OF A NEUTRON ACTIVATION METHOD. Landstrom, O.; Samsahl, K.; Wenner, C. G. (Aktiebeolaget Atomenergi, Stockholm (Sweden)). Oct. 1967. 40p. Dep.

A neutron activation method for multi-elemental analysis was applied to argillaceous deposits from the Viskan Valley on the Swedish West Coast, an area in which transgressions and regressions of the sea have occurred during the postglacial time. In a preliminary test on four samples, taken from two marine layers and two lacustrine layers, altogether 30 elements were quantitatively determined, namely As, Br, Ca, Ce, Co, Cr, Cs, Eu, Fe, Ga, Hf, Hg, La, Lu, Mn, Na, Rb, Sb, Sc, Se, Sm, Sr, Ta, Tb, Th, U, W, Yb, Zn, and Zr. Several elements showed a difference in concentration between the marine and the fresh-water layers. Br, Hg, Mn, Se, As, and Sb were more thoroughly investigated in three boreholes from different sections of the valley. Br and Se had high means in the most pronounced marine samples of the fiord deposits. Moreover, Mn showed a fourfold increase just in the transition stage between the older sea fiord and the older lage stage. (auth)

1945 (CEA-R-3220) DETERMINATION ANALYTIQUE DU PLUTONIUM DANS L'ENVIRONNEMENT. (Analytic Determination of Plutonium in the Environment). Ballada, Jean (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). June 1967. 157p. (In French). Dep.

Studies on the determination of the plutonium content in fallout from nuclear explosions are described. The importance of the problems due to the plutonium, the physico-chemical properties of the radio-element, and the biological dangers that it presents are discussed. A detailed and critical analysis was made of the radio-toxicological determination of plutonium as previously reported in the literature. Techniques for the determination of plutonium in air, rain-water, soils, and plant ash are presented. After a detailed description of the measurement equipment and the operational techniques which have been developed, a justification of these techniques is given with particular reference to their sensitivity and specificity. The results are then discussed in the case of each element in which plutonium was determined. The importance of the occurrence of fall-out plutonium on problems relating to public health is considered. From a consideration of 200 analyses carried out, it was concluded that the contribution of plutonium to the exposure of populations is still very small compared to that of natural radiation and that due to such fission products such as strontium-90. (63 references). (auth)

1946 (CEA-R-3272) DETERMINATION DE LA QUANTITE DE MATIERE FISSILE PRESENTE DANS UN ECHANTILLON PAR IRRADIATION AU MOYEN D'UNE SOURCE PULSEE DE NEUTRONS ET COMPTAGE DES NEUTRONS RETARDES. (The Determination by Irradiation With a Pulsed Neutron Generator and Delayed Neutron Counting of the Amount of Fissile Material Present in a Sample). Beliard, Lucien; Janot, Pierre (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). July 1967. 91p. (In French). Dep.

A preliminary study was conducted to determine the amount of fissile material present in a sample. The method used consisted in irradiation of the sample by means of a pulsed neutron generator and delayed neutron counting. Results showed the validity of this method provided some experimental precautions are taken. A check on the residual proportion of fissile material in leached hulls seems possible. (auth)

1947 (CONF-671027-4) ANALYSIS OF ACETYLCHOLINE IN BIOLOGICAL SAMPLES BY NEUTRON ACTIVATION ANALYSIS. Pick, M. A.; Dyer, N. C.; Brill, A. B.; Sastry, B. V. R. ([Vanderbilt Univ., Nashville, Tenn.]). [nd]. 6p. Dep. CFSTI. From Nuclear Medicine Society, Lexington, Ky.

A method for determination of acetylcholine in biological samples is described. A stable, insoluble salt of acetylcholine was formed with complex anions that contain boron. When the boron complex is irradiated with thermal neutrons, the ^{10}B atoms undergo the reaction $^{10}B(n,\alpha)^{7}Li$. The alpha particles associated with this reaction are detected in the thermal neutron beam and the amount of acetylcholine determined. The method was found to be accurate and reproducible for determination of acetylcholine in amounts as low as 3×10^{-4} grains. (M.C.G.)

1948 (EUR-3565e) THE DETERMINATION OF OXYGEN IN METALS BY 14-MeV NEUTRON ACTIVATION ANALYSIS. Hoste, J.; De Soete, D.; Speecke, A. (Ghent Rijksuniversiteit (Belgium)). June 23, 1967. 72p. Dep.

An automated oxygen analysis system for steel samples was elaborated, where with 14-MeV neutrons from a neutron generator the reaction $^{16}O(n,p)^{16}N$ ($T_{\frac{1}{2}} = 7.4$ s) is used. A fast double pneumatic transport system for rectangular 18 g samples was constructed, which allows the standard to be activated at the same time as and behind the sample. The ^{16}N γ activities are measured above 4.5 MeV with two separated counting systems. Interferences from B and F are given. Sensitivity of the method is ~0.1 mg oxygen at maximum neutron output. Correlation between activation and reducing fusion results was extensively studied on numerous samples of different origin, and is excellent. The complete activation analysis apparatus for 38 g disk samples was industrialized in a steel work. As an extension to the steel analysis oxygen determination in 11 different nonferrous metals, Al, Bi, Cd, Co, Cu, Nb, Pb, Ta, Ti, Zn and Zr was studied. Possible matrix effects on the oxygen standards were investigated and found to be negligible. Whereas most matrices do not interfere with the ^{16}N measurement, Pb and Zr interfere seriously, Al and Cu to a lesser degree. By slight changes in the measurement period of the analysis, these errors could be eliminated. (auth)

1949 (GEAP-5354) DETERMINATION OF ^{148}Nd IN IRRADIATED URANIUM AND PLUTONIUM AS A MEASURE OF BURNUP. Rider, B. F.; Ruiz, C. P.; Peterson, J. P. Jr.; Smith, F. R. (General Electric Co., Pleasanton, Calif. Nuclear Technology Dept.). Oct. 30, 1967. Contract AT(04-3)-189. 30p. Dep. CFSTI.

Nonradioactive fission-product ^{148}Nd was determined by isotopic dilution mass spectrometry. The isotopic diluent was a blend of ^{150}Nd, ^{233}U, and ^{242}Pu. After an ion exchange separation of Pu, U, and Nd, each fraction was mounted on a Re filament for mass spectrometric analysis. Burnup (atom percent fission) was computed from the ^{148}Nd-to-fuel ratio to an accuracy of 1.2% (1 σ), which includes a 0.7% single instrument uncertainty in the ^{148}Nd-to-fuel ratio and a 1.0% uncertainty in the ^{148}Nd fission yield. (auth)

1950 (JAERI-1148) USE OF EXTRACTION-PHOTOMETRIC TECHNIQUE IN ACTIVATION ANALYSIS. DETERMINATION OF GALLIUM AND INDIUM IN ALUMINUM AND ZINC. Motojima, Kenji; Hashitani, Hiroshi; Bando, Shoji; Yoshida, Hideyo (Japan Atomic Energy Research Inst., Tokyo). June 1967. 11p. Dep.

The use of the extraction-photometric technique both for the separation of the desired nuclide and for the determination of chemical yield in activation analysis has been investigated. As a first attempt, the methods for determining traces of gallium and indium in aluminum and zinc by use of 2-methyloxine have been established. An aluminum or zinc sample which had been irradiated with a neutron flux of $10^{11}/cm^2$ sec for 2 hours and cooled for a suitable time (10 hours fir gallium and 15 minutes for indium) was dissolved in hydrochloric acid. Gallium-72 or ^{116m}In was extracted into chloroform with 5 mg of each carrier, as the 2-methyloxine complex under a suitable condition, respectively. The radioactivity and the absorbance were measured with different portions of the chloroform solution. The radioactivity was corrected for the chemical yield which was obtained from the photometric measurement. Gallium or indium was determined from the radioactivity by comparison with that of each standard. The proposed methods were simple and rapid, and were useful to determine concentrations down to 0.5 ppM of gallium and as low as 0.1 ppM-level of indium. The interferences of other impurities were investigated both radiometrically and photometrically. (auth)

1951 (JUL-465-RC) ZUR KOMPLEXCHEMIE UND POLAROGRAPHIE DES TECHNETIUMS. (Complex Chemistry and Polarography of Technetium). Schwochau, K. (Kernforschungsanlage, Juelich (West Germany). Institut fuer Radiochemie). Apr. 1967. 83p. (In German). Dep.

For characterization of the complex chemistry and polarography of Tc, the crystal structures, absorption spectra, magnetic moments, electron spin resonance spectra, ligand exchange velocities, and complex formation constants were measured on halogen technetates(IV) and compared with the properties of analogous compounds of the homologous element Re. The polarographic reductions of pertechnetate ions with direct-current and alternating-current polarography by conductometric and radiometric determination of the diffusion coefficients of TcO_4^- were investigated. Application of polarography to the determination of Tc was also studied. (tr-auth)

1952 (KFK-560) BESTIMMUNG VON THORIUM UND URAN DURCH ROENTGENFLUORESZENZANALYSE. (Determination of Thorium and Uranium by X-Ray Fluorescence Analysis). Ertel, D.; Wettstein, W. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Heisse Chemie). Mar. 1967. 26p. (In German). Dep.

Individual and simultaneous determinations of Th and U in aqueous solution can be carried out on the basis of intensity measurements of the corresponding $L_{\alpha 1}$ lines. In the Th/U simultaneous determinations Sr was used as internal standard. Under the excitation conditions of 55 kV and 32 mamp (W tubes) the measurement region for individual determinations is 0.005 to 10 mg/ml and the sensitivity lies at 10^5 pulses/mg/ml. The detection limit is 2.4 μg Th/ml and 2.6 μg U/ml. In the optimum measurement region of 0.1 to 10 mg/ml the standard deviation of the method is ±1.5%. The time expenditure for an analysis is 15 and 30 minutes for individual and simultaneous determinations, respectively. In series analysis this time expenditure can be reduced to 5 or 10 minutes per analysis. (tr-auth)

1953 (KFK-570) PHOTOMETRISCHE BESTIMMUNG DES ISOTOPENGEHALTES VON SCHWEREM WASSER. (Photometric Determination of the Isotopic Content of Heavy Water). Feuerstein, Horst (Kernforschungszentrum, Karlsruhe (West Germany)). May 1967. 37p. (In German). Dep.

Methods for determination of the isotopic content of water samples using a spectrophotometer are described. By application of a difference method it was possible to analyze samples with 99.2 to 99.7 mol.% D_2O to ±0.0015 mol.%, samples with 0 to 5 and 95 to 100 mol.% D_2O to ±0.01 mol.%, and samples with 0 to 100 mol.% D_2O to ±0.2 mol.% accurately. These accuracies are relative accuracies as an error in the determination of the concentration of the standard water affects the absolute value of the measurement results. The method is fast and has few interferences. Differences in the content in heavy oxygen isotopes as can occur in samples of heavy water do not affect the measurement. Sampling and measurement techniques are described. (tr-auth)

1954 (LA-DC-8994) THE DETERMINATION OF OXYGEN AND CARBON IN GERMANIUM BY ^3He ACTIVATION. Holm, Dale M.; Briscoe, William L.; Parker, Jack L.; Sanders, Wm. Mort; Parker, Sam H. (Los Alamos Scientific Lab., N. Mex.). 1967. Contract W-7405-eng-36. 31p. (CONF-670947-1). Dep. CFSTI.

From 2nd International Meeting on Practical Aspects of Activation Analysis with Charged Particles, Liege, Belgium.

Channeling of ^3He ions in single-crystal germanium and its application to activation analysis is being investigated. Crystal orientation was determined by directing a beam of low angular divergence and energy onto the crystal and observing the decrease in counting rate from Rutherford backscattered particles as a function of incident beam angle. Some samples were activated with the beam aligned along the [111] axis of the crystal and others with the beam purposely misaligned from that axis. Samples of germanium from different sources were analyzed, and typical values of 10 ppM oxygen and 40 ppM carbon were obtained. Slight activation of the germanium was found at 6.5 MeV and serious activation at 8 and 12 MeV. Autoradiography was performed on some of the samples following activation to aid in the interpretation of the results. (auth)

1955 (LFEN-NI.-26a) UM METODO DE ANALISE DO COBRE SERICO POR RADIOACTIVACAO COM NEUTROES. (Neutron Activation Analysis of Copper Compounds). de Carvalho, Antonio Manuel Brito (Junta de Energia Nuclear, Sacavem (Portugal). Laboratorio de Fisica e Engenharia Nucleares). 1965. 148p. (In Portuguese). Dep.

A sensitive radioactivation method for the determination of Cu complexes in the blood is described. The sensitivity of the method compared favorably with the sensitivity of other methods. The laboratory techniques for the radioactivation method are described in detail. (J.S.R.)

1956 (MLM-1405) MOUND LABORATORY PROGRESS REPORT FOR CHEMISTRY, JANUARY-MARCH 1967. (Mound Lab., Miamisburg, Ohio). Mar. 31, 1967. Contract AT-33-1-GEN-53. 62p. Dep. CFSTI.

Developments are reported for studies on: determination of coincidence correction; half-life determination by decaying pairs; residue adsorption; alpha-beta branching ratio of ^{227}Ac; half-life of ^{216}Po; thermal dehydration of uranyl nitrates; studies of catalyst for dissolution of Pu(IV) oxide; chelates of Eriochrome Blue Black-R; separation of small quantities of B in KCl-KF; ^{234}U recovery; ^{229}Th recovery; techniques for measuring internal conversion coefficients; gamma assay of ^{238}Pu in waste; determination of ^{95}Zr and ^{95}Nb by gamma counting; NMR analyses of tropolone complexes of U; spectrographic studies of lead analysis; spectrographic analysis of Si; stilbene crystal, fast-neutron spectrometer; modified electron beam measurement of thermal diffusivity; and x-ray diffraction analysis. (P.C.H.)

1957 (ORNL-IIC-10(Vol.1), pp 336-55) BALANCED FILTERS FOR THE ANALYSIS OF Al, Si, K, Ca, Fe, AND Ni. Dunne, James A.; Nickle, Neil L. (Jet Propulsion Lab., Pasadena, Calif.).

The balanced filter technique offers a satisfactory method of dispersion in the Z region studied. The primary x-ray flux available at the sample surface is more than adequate to allow x-ray fluorescence determination of the elements Al, Si, K, Ca, Fe, and Ni when they exist in the sample in amounts greater than one per cent by weight. The Cu target x-ray tube is, however, far from optimum for the determination of Al and Si. The relatively poor performance on Si and Al, combined with escape peak interference with Ca and K analyses, suggests the use of Ne rather than Ar counting gas in this particular application. (auth)

1958 (ORNL-IIC-10(Vol.1), pp 442-64) OPTIMIZATION OF EXCITATION AND DETECTION TECHNIQUES FOR ANALYSIS OF SILVER ORES BY RADIOISOTOPE X-RAY SPECTROMETRY. Rhodes, J. R. (Texas Nuclear Corp., Austin).

A method for x-ray fluorescence determination of silver in ores is described in which the AgK x rays are excited by a radioisotope source-target assembly ($^{241}Am/I$) emitting spectrally pure IK x rays. The detector used is a cooled, lithium-drifted silicon diode with a low noise preamplifier employing a cooled, field-effect transistor. The detection system has a resolution for AgK_α x rays of 580 eV. With this optimized excitation and detection technique, the detection limit for silver in ores was 22 ppM in a count time of 4 minutes with a primary source activity of 14 mCi. Tests with fifteen analyzed natural ore samples from different locations showed severe matrix effects when the AgK_α flux was plotted as a function of silver content. When the ratio AgK_α to Compton-scattered IK_α flux was used, the correlation with silver content improved to such an extent that all but three of the ores fell on the same calibration curve, within the limits of statistical error. (auth)

1959 (ORNL-IIC-10(Vol.1), pp 465-82) X-RAY-FLUORESCENT ANALYSIS OF MULTIPLE COMPONENT SAMPLES BY A NONDISPERSIVE SYSTEM. Jones, W. Barclay; Carpenter, Robert A. (Technical Measurement Corp., San Mateo, Calif. Special Products Div.).

A nondispersive x-ray-fluorescent-analysis system for use in analyzing diluted multiple-component samples is discussed. The system uses a radioactive source to excite the characteristic x-rays of the sample and a lithium-drifted semiconductor detector to detect these x rays. This method of analysis is made possible by recent advances in solid-state detection resolution and electronic circuitry, which led to the superior energy discrimination

needed to resolve x rays of elements. Tests showed that less than 100 ppM of several elements can be simultaneously identified. Accuracy of measurements is discussed in terms of sensitivity and time needed for the measurements. Matrix effects are discussed. (auth)

1960 (ORNL-IIC-10(Vol.1), pp 483-502) ANALYSIS FOR MEDIUM-WEIGHT-ELEMENTS BY GAMMA-EXCITED X-RAY FLUORESCENCE. Hollstein, Martin G. (Kernforschungszentrum, Karlsruhe (West Germany)); DeVoe, James R. (National Bureau of Standards, Washington, D. C.).

The application of gamma-excited x-ray fluorescence in the determination of the amount of medium weight elements was studied. The pertinent components of the spectrometer are an ^{241}Am source and a solid state detector, with a low-noise preamplifier and multi-channel analyzer. The resolution of the system is between 1.2 and 1.3 keV (FWHM) for 8- to 45-keV photons. Three different techniques of sample mounting were investigated. For single elements in the range from Cu to Dy the estimated detection limits are 10 to 100 μg and 0.01 to 1 mg/ml, depending on the sample mounting procedure. The corresponding K_α-peak intensities are 2×10^4 to 3×10^3 cpm per mg and 4×10^4 to 6×10^2 cpm per mg/ml, respectively. For testing the application of the method two series of NBS Standard Reference Materials were analyzed for Sn and Mo as minor constituents within a concentration range from about 0.04 to 9%. The best results were obtained by direct counting of the solid samples. Using this technique, a nondestructive analysis for Mo and Sn can be performed in a relatively short time with a precision of a few percent, a detection limit of about 100 ppM, and a sensitivity of 6×10^3 to 1.4×10^4 cpm/% concentration. (auth)

1961 (ORO-2980-17) APPLICATIONS OF NEUTRON ACTIVATION TO ON-STREAM ANALYSIS. Rhodes, J. R. (Texas Nuclear Corp., Austin). Oct. 26, 1967. Contract AT (40-1)-2980. 31p. (CONF-671112-2). Dep. CFSTI.

From 8th Conference on Radioisotopes and Exhibition of Nuclear Instruments, Materials and Products, Tokyo, Japan.

Nuclear techniques for process analysis are reviewed. Some comments are made on applications of radioisotope and accelerator neutron sources, and on detection of the prompt or delayed gamma rays by spectrometric, coincidence and anticoincidence counting techniques. Different methods of sample presentation are surveyed, including semi-automatic batch sampling, conveyor belt presentation of bulk materials, and continuous presentation of liquids and slurries. Applications include determination of oxygen in steel; nitrogen in food products; fluorine in fluoride minerals; aluminum in bauxite and cement; silicon in iron and a number of ores, and copper in copper ores. (auth)

1962 (PG-Report-806) ANALYTICAL METHOD FOR THE DETERMINATION OF NORMAL BUTYL ALCOHOL IN TRIBUTYL PHOSPHATE (GAS CHROMATOGRAPHY). Hughes, E.; Chadwick, L. B. (United Kingdom Atomic Energy Authority, Sellafield (England). Production Group). 1967. 5p. Dep. CFSTI. UK 1s. 2d.

A known weight of n-tridecane is added to the sample. The mixture is chromatographed on a Celite column containing 10% by weight of polyethylene glycol 400 and the ratio of the heights of the peaks due to n-tridecane and n-butyl alcohol is used to obtain the concentration of n-butyl alcohol. The precision (three times the coefficient of variation) is ±9%, based on 11 results at the 0.05% w/w level. (auth) (UK)

1963 (RFP-990) DETERMINATION OF CERIC OXIDE IN LEAD BY X-RAY FLUORESCENCE. Hayden, J. A. (Dow Chemical Co., Golden, Colo. Rocky Flats Div.). Aug. 7, 1967. Contract AT(29-1)-1106. 10p. (CONF-670827-1). Dep. CFSTI.

From Rocky Mountain Spectroscopy Conference, Denver, Colo.

Three methods described for determining CeO_2 in Pb by x-ray fluorescence. The techniques are applicable to the concentration of CeO_2 ranging from ppM to major constituent levels. Ion exchange in a bromide medium is used to separate Pb from micro amounts of Ce. Microgram amounts of Ce are concentrated on ion exchange paper for analysis. Higher concentrations of Ce are analyzed in solution. Samples containing >five percent CeO_2 are analyzed without separating Ce from Pb. The relative standard deviations are 6, 2.4, and 1.1%, respectively, for the micro, macro, and high level techniques. (auth)

1964 (RFP-1001) ANALYSIS OF LEAD ALLOYS BY ATOMIC ABSORPTION SPECTROPHOTOMETRY. Shepherd, G. A.; Johnson, A. J. (Dow Chemical Co., Golden, Colo. Rocky Flats Div.). Aug. 7, 1967. Contract AT(29-1)-1106. 23p. (CONF-670827-2). Dep. CFSTI.

From Rocky Mountain Spectroscopy Conference, Denver, Colo.

The determination of tin in tin–lead alloys and the determination of calcium in calcium–lead alloy is accomplished by atomic absorption spectrophotometry. Solutions of the samples are analyzed using a Perkin Elmer Model 303 Atomic Absorption Spectrophotometer equipped with a 10-cm pre-mix acetylene–air burner. Tin–lead alloy samples are dissolved using fluoroboric acid, tartaric acid, and a small amount of nitric acid. Replicate analyses of an NBS lead alloy containing 4.94% tin gave an average result of 4.93% with a relative standard deviation of 2.66%. The calcium–lead alloys are put into solution with nitric acid, and lanthanum is added to eliminate possible interferences. Recoveries on prepared synthetic samples averaged nearly 100%. The relative standard deviation at a calcium content of 640 ppM was 0.30%. (auth)

1965 (UCRL-17812) SIMULTANEOUS DETERMINATION OF ^{18}O AND ^{16}O ISOTOPES BY ^3He ACTIVATION ANALYSIS. Lamb, James F.; Lee, Diana M.; Markowitz, Samuel S. (California Univ., Berkeley. Lawrence Radiation Lab.). Oct. 1967. Contract W-7405-eng-48. 11p. (CONF-670947-2). Dep. CFSTI.

From 2nd International Meeting on Practical Aspects of Activation Analysis with Charged Particles, Liege, Belgium.

The isotopic content of oxygen in various materials may be determined by nuclear reactions induced in oxygen during bombardment by $^3He^{2+}$ ions accelerated to about 10 MeV. The reactions of interest are: $^{16}O(^3He,p)^{18}F + {}^{16}O(^3He,n) = {}^{18}Ne \rightarrow {}^{18}F$ and $^{18}O(^3He,p)^{20}F$. The accuracy and sensitivity are both concerned primarily with counting statistics which, in turn, are governed by available beam current. (M.C.G.)

1966 (UCRL-17824) AMPEROMETRIC TITRATION OF PALLADIUM(II) BY OXIDATION WITH HYPOCHLORITE. Clem, Ray G.; Huffman, E. H. (California Univ., Berkeley. Lawrence Radiation Lab.). Sept. 1967. Contract W-7405-eng-48. 16p. (CONF-671012-3). Dep. CFSTI.

From 11th Conference on Analytical Chemistry in Nuclear Technology, Gatlinburg, Tenn.

The titration of palladium(II) by oxidation with hypochlorite to palladium(IV) is made feasible through the stabilizing influence of a 0.5 M azide supporting electrolyte at pH2 to 3 on the palladium(IV) species, resulting in a marked reduction of the oxidation potential of the Pd(IV)/Pd(II) couple. The titration end point is detected with a rotated platinum electrode at 0.5 V versus a saturated calomel electrode. The method is most useful in the range (0.5–2.1 mg Pd) slightly above that covered by spectrophotometry and below that conveniently amenable to gravimetry, with a precision of about 0.5 percent. High ratios of common metals and platinum to palladium are tolerated. Deviations from the expected 2 : 1 hypochlorite to palladium ratio were found while developing the procedure; these deviations are of no consequence when the titrant is standardized against palladium. The effects of chloride concentration, azide concentration, pH, temperature, time of titration, photoreduction and concentration of palladium(IV) on the ratio were studied. Formal potential measurements of the Pd(IV)/Pd(II) couple in the recommended supporting electrolyte gave values from 0.64 to 0.53 V on changing the pH from 2 to 3, with an attendant 10-fold increase in azide ion concentration. (auth)

1967 (Y-1590) EMISSION SPECTROGRAPHIC ANALYSIS OF PURIFIED CALCIUM METAL. Stewart, J. H. Jr.; Neff, C. M. (Union Carbide Corp., Oak Ridge, Tenn. Y-12 Plant). Nov. 14, 1967. Contract W-7405-eng-26. 14p. Dep. CFSTI.

A successful method for determining fifteen trace impurities in pure calcium was developed. The average limit of error at the 95% confidence level for the fifteen elements determined was ±16.3% at the lowest level and ±14.9% at the highest level. The simplicity of sample preparation and utilization of dc arc excitation provide improved accuracy at a lower cost when compared to the emission spectrographic analysis of calcium oxide previously used. (auth)

1968 (CEA-tr-X-630) TITRAGE POTENTIOMETRIQUE DE L'URANIUM VI OU DE L'URANIUM IV EN SOLUTION DANS L'ACIDE PHOSPHORIQUE. DOSAGE DE L'OXYDE D'URANIUM. (Potentiometric Titration of U(VI) or U(IV) in Solution in Phosphoric Acid. Determination of Uranium Oxide). Nakajima, Fuminari; Sakai, Kaoru. Translated into French from Nippon Kagaku Zasshi, 85: 40-4(1964). 26p. (In French). Dep. CFSTI. JCL $2.60 fs, $0.98 mf.

Methods for the potentiometric titration of U(VI) or U(IV) in a phosphoric acid solution were studied. For U(VI) the methods consisting of the reduction to U(IV) by Ti(III) and the subsequent titration of U(IV) by an excess of potassium bichromate was first examined. As a solution of Ti(III) it is easy to use a solution prepared by dissolving metallic Ti with heating in concentrated phosphoric acid, because it is stable, being hardly oxidized by the air. When the U, after reduction, is titrated by potassium bichromate the potential varies in two stages. If the temperature of the solution is high, the variation of the potential is slow in the

vicinity of the first end point, that is to say the point where the excess of Ti(III) begins to be oxidized. If the solution is heated to 95°C the potential varies rapidly, which makes the end point sharp. The second end point is always sharp no matter what the temperature of the solution. For U(IV) the method consisting of titrating it directly by potassium bichromate was examined. If metallic U or U(IV) in a compound is attacked on heating by concentrated phosphoric acid, it dissolves quantitatively taking the form of tetravalent ions. If it is heated during titration, a dilute solution after dissolution in the concentrated phosphoric acid and a small fraction of the U(IV) is oxidized by the air. It is then better to do the titration at room temperature. By combination of these two methods it is possible to determine in a single series of operations U(IV) and U(VI) contained in a single sample. (tr-auth)

1969 RADIOACTIVATION DETERMINATION OF IMPURITIES IN GALLIUM ARSENIDE. Artyukhin, P. I.; Gil'bert, E. N.; Pronin, V. S. Radiokhimiya, 9: 341-6(1967). (In Russian).

A radioactivation method is proposed for determining Cu, Zn, Cd, Ag, In, Re, Pd, Ir, W, Co, K, and Na in gallium arsenide, these elements being separated by extraction. The distribution of Sc(III), Te(IV), Sn(IV), As(V), Ta(V), and W(VI) between a 5% solution of di-n-butylthiophosphoric acid (DBTPA) in CCl_4 and HCl solutions was studied by determining the distribution coefficients with the aid of radioactive tracers, and the results were used to work out the separation scheme. Activation of the impurities in gallium arsenide samples involved irradiation with a neutron flux of 1.8×10^{13} n/cm² sec for 9 hr, and interpretation of the γ spectra of the separated impurities. The results of the analysis were reproducible to within ±10%. (ATD)

1970 MICROAUTORADIOGRAPHIC METHOD FOR DETERMINATION OF ^{232}Th AND ^{228}Th ISOTOPES IN BIOLOGICAL MATERIALS. Korobkov, V. I.; Pavlovskaya, N. A.; Selezneva, V. V. Radiokhimiya, 9: 365-70(1967). (In Russian).

A method for the microautoradiographic determination of ^{232}Th and ^{228}Th in biological materials is proposed. The sensitivity of the method is 10^{-7}g of ^{232}Th in biological material. Isotopes of U, Ra, and other α-emitting elements do not hinder the determination. (tr-auth)

1971 DETERMINATION OF GOLD CONTENT IN SILVER BY ACTIVATION ANALYSIS METHOD. Rimskii-Korsakov, A. A.; Smirnov, A. A.; Smirnov, V. V.; Chubarov, M. N. Radiokhimiya, 9: 388-9(1967). (In Russian).

A method for the neutron activation determination of gold in refined silver without destruction of the sample was developed. The method is based on the measurement of the γ spectrum of radioisotopes formed in the activation. The absolute quantity of gold detectable in the analysis was 3.5×10^{-9} g. (J.S.R.)

1972 DETERMINATION OF RHENIUM IN RHENIUM–TUNGSTEN ALLOY. Okubo, Teiji; Kojima, Masuo (Government Chemical Industrial Research Inst., Tokyo). Bunseki Kagaku, 16: 1082-4(Oct. 1967). (In Japanese).

The spectrophotometric determination of rhenium according to the thiourea method has been applied to rhenium–tungsten alloy. A sample of the alloy was fused with a mixture of sodium carbonate and potassium nitrate, and it was dissolved in water and then diluted. An aliquot of the solution containing 0.1 to 2.0 mg of rhenium is taken in a volumetric flask and diluted to 100 ml, after the addition of 0.2 g of urea, 10 ml of 50% citric acid solution, 25 ml of concentrated hydrochloric acid, 12 ml of 5% thiourea solution, and 6 ml of 1 M stannous chloride in 4 M hydrochloric acid solution. More than 50 minutes later, the absorbence is measured at 380 mμ. The method can be applicable to the rapid determination of rhenium in rhenium–tungsten alloy without separating any rhenium from a large quantity of tungsten. (auth)

1973 DETERMINATION OF FLUORIDES IN PHOSPHATE SOLUTIONS BY TITRATION WITH THORIUM NITRATE. Marecek, Vladimir; Brezina, Bohuslav (Inst. of Physics, Prague). Chem. Listy, 51: 1230-3(Sept. 1967). (In Czech).

A method for determination of F^- in the presence of PO_4^{3-} by titration with thorium nitrate was developed. The PO_4^{3-} was removed from the solution as insoluble cadmium phosphate. The pH of the solution was adjusted to 3.4 and sodium alizarin sulfonate was used as indicator and the solution titrated with a thorium nitrate solution to a deep orange-yellow color. In the region from 0.19 to 38 mg F the average error amounted to a maximum of 3.8%. (tr-auth)

1974 DETERMINATION OF TRACE AMOUNTS OF CHLORIDE IN URANYL SALTS. Morozumi, Takashi; Ohashi, Hiroshi (Hokkaido Univ., Sapporo). J. Nucl. Sci. Technol. (Tokyo), 4: 540-2(Oct. 1967).

A new electrometric method, the pCl-static method, was developed for the determination of trace amounts of chloride in uranyl salts. The pCl-stat consists of two main parts—an electrolytic cell provided with an Ag–AgCl electrode of relatively large surface area, and an electronic potentiostat of chopper type specially devised to obtain high stability of potential. Details of the procedure and calculations are presented. (J.G.B.)

1975 GAMMA-ACTIVATION ANALYSIS. Baker, C. A. (Atomic Energy Research Establishment, Harwell, Eng.). Analyst, 92: 601-10(Oct. 1967).

A review on gamma activation analysis is presented, which includes information on: types of gamma activation; nuclear considerations for (γ,n) reactions; electron accelerators; nature of the product nuclides; determination of light elements, O, N, C, and F; and determination of heavier elements of atomic numbers equal to, or greater than, 10. The intrinsic sensitivity of gamma activation analysis is appended. (P.C.H.)

1976 AMPEROMETRIC ESTIMATION OF URANIUM WITH 2' 3' 4'-TRIHYDROXYCHALCONE. Syamasundar, K. (Sri Venkateswara Univ., Tirupati, India). Curr. Sci. (India), 36: 607-8(Nov. 20, 1967).

The reaction of 2', 3', 4'-trihydroxychalcone with UO_2^{2+} ions at pH 5.9 to 8.4, yielding an orange-red precipitate was investigated for amperometric estimation of uranium. It is shown that 2.38 to 14.29 mg of uranium can be estimated with an error of about 1%. (M.C.G.)

1977 QUANTITATIVE ANALYSIS OF FISSILE MATERIALS BY DELAYED NEUTRON EMISSION. Terrani, M.; Terrani, S. (CESNEF-Politenico, Milan). Energ. Nucl. (Milan), 14: 638-42(Nov. 1967).

A method for the simultaneous determination of uranium and thorium in uranium–thorium mixtures, based on measurement of the delayed neutron emission following fission, is described in detail. The limits of applicability of the method are pointed out and discussed. (auth)

1978 SPECTROPHOTOMETRIC STUDIES OF RUTHENIUM (III) AND RHODIUM(III)–OXIMIDOBENZOTETRONIC ACID COMPLEXES AND THE SIMULTANEOUS DETERMINATION OF THE TWO METALS. Manku, G. S.; Bhat, A. N.; Jain, B. D. (Univ. of Delhi). Talanta, 14: 1229-36(Nov. 1967).

Ruthenium(III) and rhodium(III) form stable coloured complexes in ethanolic solution with oximidobenzotetronic acid (OBTA). Ruthenium forms a purple-violet $Ru(OBTA)_3$ complex at pH 1.1 to 3.5, which is stable over the pH range 1.1 to 11.3. Rhodium(III) forms a yellowish-brown complex, $RhCl_2(OBTA)_2$, at pH 2 to 8; at higher pH (11.5 and above) the complex is reddish-brown, but has the same Rh : OBTA ratio. A method for the simultaneous determination of these two metals is proposed, and the interference by commonly occurring ions was investigated. (auth) (UK)

1979 COLORIMETRIC DETERMINATION OF SMALL AMOUNTS OF NIOBIUM IN STEEL AFTER SEPARATION BY ANION EXCHANGE. Danielsson, L. (Swedish Inst. for Metal Research). Jernkontorets Ann., 151: 325-39(1967).

A method was developed for determination of small amounts of niobium in steel. Although mainly designed for mild and low-alloy steels it was thought that the method could be used also for other types of steel alloyed with niobium. Niobium is separated from iron and several other elements by adsorption on 1.5 g of an anion exchange resin from a solution of 1N HF-0.05N HNO_3. Niobium, which is held strongly by the resin, is eluted with 4N HNO_3–1N HF. After removal of the hydrofluoric acid a coloured complex of niobium with 4-(2-pyridylazo)-resorcinol (PAR) is developed and measured. Suggestions to speed up the procedure are made. (auth) (Sweden)

1980 RAPID ANALYTICAL METHODS FOR INVESTIGATION OF METALS AND INORGANIC RAW MATERIALS. XVI. PHOTOMETRIC DETERMINATION OF URANIUM TRACES IN WATER AFTER PREVIOUS SEPARATION ON CHELATE EXCHANGERS. Sulcek, Z.; Povondra, P. (Zentralinstitut fuer Geologie und Geologisches Institut, Prague). Collect. Czech. Chem. Commun., 32: 3140-8(Sept. 1967). (In German).

Selective separation of uranium traces, with the help of the chelate exchanger Dowex A-1, from other metal ions that disturb the photometric determination of uranium using Arsenazo was investigated. Uranyl ions were sorbed from solutions at pH 6 to 8 in the presence of EDTA on chelate exchangers. Distributions and elution of the complexes of some metal ions were followed. Optimum conditions for color reactions of the uranyl ions with Arsenazo were investigated. This separation method, in combination with the photometric method for uranium determination, was used

for surface as well as strongly mineralized waters. The lowest uranium concentration that could be determined was 5 ppB. (tr-auth)

1981 DETERMINING IMPURITIES IN HIGH-PURITY NIOBIUM. Kuznetsova, N. N.; Krauz, L. S. pp 66-72 of Metallovedenie i Termicheskaya Obrabotka Metallov. Moscow, Atomizdat, 1966. (In Russian).

Iron, Si, Ti, and Pb impurities are determined by the direct spectrographic method with a sensitivity of 1×10^{-3}%; for Ta the sensitivity is 3×10^{-2}%. Iron, Mn, Mo, W, Cu, Ni, Zr, Pb, P, Sn, Ta, and Ti impurities are determined by chemical methods using separate weighed amounts. The Nb interferes with determination of most of the elements. Pb, Cd, and Bi are first separated by extracting them, in the form of diethyldithyocarbamates, with chloroform from alkaline solution. The chemical–spectrographic method of determining the Bi, Gd, Sb, Sn, and Pb impurities in metallic W, Nb, and Ta consists of first concentrating the impurities by precipitation in the form of sulfides on a CuS carrier and determining them spectrographically in the concentrate with an ISP-22 spectrograph. The sensitivity of the method is $3 \times 10^{-4} - 5 \times 10^{-5}$%. The chemical-spectrographic method of simultaneously determining 15 impurity elements in metallic Nb consists of concentrating the impurities chemically, followed by spectrographic analysis. The sensitivity with which the elements are determined is 2×10^{-3} to 6×10^{-5}% and the error is 15 to 20% (relative). (Rev. Met. Lit.)

1982 ISOTOPIC ANALYSIS OF URANIUM. SPECTROGRAPHIC DETERMINATION OF ^{235}U–^{238}U RATIOS. Rossi, G. (Euratom-CCR, Ispra, Italy); Hainski, Z.; Omenetto, N. Met. Ital., 16: 641-4(July 1967). (In Italian).

The possibilities of establishing a reliable optical spectral method for determination of $^{235}U/^{238}U$ ratios were investigated with dc arc excitation and photographic recording. Overlapping of the spectral orders was eliminated with gelatin filters or with an interference band filter peaked at 4240 Å. With the line pair ^{235}U 4244,122-U 4243,546, a coefficient of variation (σ) equal to 5.62% at the level of naturally occurring uranium was obtained. An improvement of the precision (±2,2% at 1% ^{235}U) was achieved when the uranium spectrum was excited in a hollow cathode lamp operated at high discharge current (500 mA). Preliminary results compared to mass spectroscopy values are presented. (auth)

1983 INTERFERENCES ENCOUNTERED IN 14 MeV NEUTRON ACTIVATION ANALYSIS. Mathur, S. C.; Oldham, G. (Loughborough Univ. of Tech., Eng.). Nucl. Energy, 136–41 (Sept.-Oct. 1967).

A compilation was made of the interferences that may be encountered in activation analysis using 14-MeV neutrons. This indicates reactions that will produce the same product nuclide and also shows the instrumental interference that will be encountered with nuclides having similar half-lives and similar gamma energies. (auth) (UK)

1984 SOME EXPERIMENTS ON THE APPLICATION OF LASER SAMPLING TO EMISSION, SPECTROSCOPY; DETERMINATION OF ELEMENTS, EFFECTS OF MATERIAL STRUCTURE. Cerrai, E.; Trucco, R. (CISE, Milan). Met. Ital., 16: 615-20 (July 1967). (In Italian).

Some results of experiments in the field of emission spectroscopy, by means of a laser equipment for the localized sample evaporation, are reported. The laser microprobe is used, coupled with a spark secondary discharge, to carry out microanalyses of different samples. Analyses of steel compositions, analyses of thin oxide layers on zirconium alloys, and researches on metal sample microstructure are described. Use of laser microprobe is pointed out as a means to make spectroscopy fit for microanalyses, not as a substitute for usual excitation methods with integration. (auth)

1985 UTILIZATION OF AN INDUCTION PLASMA IN THE ANALYSIS OF TRACES BY ATOMIC ABSORPTION. Biancifiori, M. A.; Bordonali, C. (CSN, Casaccia, Italy). Met. Ital., 16: 631-8(July 1967). (In Italian).

Some experiments on atomic absorption, performed by using an induction plasma instead of the conventional flame, are reported. Several elements, such as Zn, Ni, Ag, Mn, Pb, Fe, Mg, Pt, Cu, Co, Cr, Al, Cs, and some rare earths were taken into consideration. The use of plasma involves very high temperatures, a long residence time (which facilitates the formation of free atoms) and also the possibility of introducing reducing agents in any form, in order to analyze elements that produce refractory compounds. A study of possible chemical interferences is included. (auth)

1986 QUANTITATIVE DETERMINATION FOR GADOLINIUM IN THE GRAPHITE OF REACTORS. Ruessmann, H. H. (Ringdsorf-Werke GmbH, Bad Godesberg, Ger.). Met. Ital., 16: 639-40(July 1967). (In Italian).

Studies with quartz spectrographs were undertaken in order to determine gadolinium in graphites of reactors; rather satisfactory results were obtained. Graphite samples were enriched through incineration, and noxious elements were eliminated by separation, chemically. Separation is required especially because of high steel contents along with the graphite in reactors. (auth)

1987 CONTROLLED POTENTIAL COULOMETRIC DETERMINATION OF URANIUM AND NEPTUNIUM IN URANIUM–NEPTUNIUM ALLOYS. Plock, C. E. (Dow Chemical Co., Golden, Colo.); Polkinghorne, W. S. Contract AT(29-1)-1106. Talanta, 14: 1356-60(Nov. 1967).

A controlled potential coulometric titration method was developed for the determination of neptunium and uranium in the presence of each other. The recovery of a neptunium standard in the presence of uranium was 100.02% with a relative standard deviation of 0.13%, and the recovery of a uranium standard in the presence of neptunium was 100.03% with a relative standard deviation of 0.13%. (auth) (UK)

1988 PHOTOMETRIC DETERMINATION OF SMALL MOLYBDENUM CONTENTS WITH PYRAZINE-2,3-DICARBOXYLIC ACID. Hartkamp, Heinrich Z. Anal. Chem., 231: 161-73(Sept. 8, 1967). (In German).

A method is given for the photometric determination of small amounts of molybdenum. It is based on the reaction between hexavalent molybdenum, 2,3-pyrazinedicarboxylic acid as chelating agent, and stannous chloride as reducing agent. In strong hydrochloric acid medium the reaction leads to the formation of a very intense violet complex compound, the light absorption of which follows Beer's law and can be measured with good reproducibility. The complex solutions are stable for several hours. Most common cations and anions, except iron and nitrate, do not interfere even when present in large excess. (auth)

1989 DETERMINATION OF TRACE ELEMENTS IN PETROLEUM OF THE MATZEN–AUERSTHAL FIELDS BY NEUTRON ACTIVATION ANALYSIS. Part I. DETERMINATION OF LONG-LIVED NUCLIDES. Patek, Peter; Bildstein, Hubert (Osterreichische Studiengesellschaft fur Atomenergie, Vienna). Z. Anal. Chem., 231: 187-94(Sept. 8, 1967). (In German).

A combination of liquid-liquid extraction, precipitation, and ion exchange allowed a separation of the elements iron, zinc, antimony, silver, chromium, cobalt, selenium, and scandium in artificial mixtures representing trace impurities of crude oils. The determinations were performed by neutron activation. The chemical yield reached 85 to 95% (reproducibility ±2% rel.). (auth)

1990 THE INFLUENCE OF DILUENTS IN THE THIOCYANATE METHOD OF DETERMINATION OF NIOBIUM BY EXTRACTION WITH TRI-n-BUTYL PHOSPHATE. Rozycki, Cezary (Politechnika, Warsaw). Chem. Anal. (Warsaw), 12: 735-40 (1967). (In Polish).

The influence of different diluents on the spectra of thiocyanate complexes of niobium and molybdenum(V) was investigated. The diluents investigated did not influence the extraction percentage of niobium and molybdenum which in all experiments was over 95%. In various diluents containing 7.5% TBP the absorption maximum was shifted towards longer wavelengths in comparison with 100% TBP. It seemed that the shift was greater for diluents with lower dielectric constants. The absorbence depended on the kind of diluent and concentration. The activities of TBP and HSCN may change differently depending on the kind of diluents. The increase of diluent concentration caused a decrease in absorbence at absorption maximum and shifted it towards longer wavelengths. The used diluents were divided into two groups: those in which influence was observed at high concentration only (CCl_4, C_6H_6); and those that influence also at low concentrations ($CHCl_3$). The diluent concentration influenced the extraction of thiocyanate complexes of iron(III); the decrease of absorbence resulted from the decrease of extraction percent because the red thiocyanate complexes of iron remain in the aqueous phase. By a proper choice of the diluent and its concentration it is possible to avoid the influence of iron in spite of some decrease of the absorbence of niobium and molybdenum thiocyanate complexes. (auth)

1991 ANALYTICAL APPLICATION OF THIOCYANOBISMUTHATES. III. A NEW METHOD OF COMPLEXOMETRIC AND GRAVIMETRIC DETERMINATION OF CAESIUM AS CAESIUM TETRATHIOCYANATOBISMUTHATE. Cyganski, Andrzej (Politechnika, Lodz, Poland). Chem. Anal. (Warsaw), 12: 765-71(1967). (In Polish).

A new method has been worked out for gravimetric and complexometric determination of cesium. The method is based on precipitation of $Cs[Bi(SCN)_4]$ using a 0.5 M solution of $H[Bi(SCN)_4]$

obtained by the reaction of $(BiO)_2CO_3$ with a 14% solution of HNCS. The HNCS solution is obtained by distillation of H_2SO_4 and NH_4NCS. Solutions saturated with cesium tetrathiocyanatobismuthate are used for the precipitation and washings because of the relatively high solubility of $Cs[Bi(SCN)_4]$. For complexometric determination, the precipitate is dissolved in HNO_3 (1 : 1) and bismuth is titrated with 0.01 M EDTA in the presence of Pyrocatechol Violet. The determination can be carried out in the presence of sodium, lithium, potassium, rubidium, ammonium, alkaline earth metals, and aluminum. (auth)

1992 A SPECTROPHOTOMETRIC STUDY OF THE INTERACTION OF SCANDIUM IONS WITH N,N'-DI(2-HYDROXY-5-SULFOPHENYL)-C-CYANFORMAZAN. Onosova, S. P.; Kuntsevich, G. K.; Lisienko, D. G. (Ural Polytechnical Inst., Sverdlovsk, USSR). Zh. Anal. Khim., 22: 1469-74(Oct. 1967). (In Russian).

Scandium combines with N,N'-bis-(2-hydroxy-5-sulfophenyl)-C-cyanformazan to form a blue compound of the anion nature at a molar ratio of 1 : 1. The complex composition has been found by means of the isomolar series method, by the molar ratio method and, besides that, by means of the Asmus straight line method modified by Klausen and Langmyhr for multinuclear complexes. The maximum absorption of the complex is at 590 nm. The molar extinction coefficient at this wave length at pH 5.2 is 13,000. The determination of scandium at pH 3.8 is possible in the presence of large amounts of yttrium and rare earth elements without its separation. (auth)

1993 A SPECTROPHOTOMETRIC STUDY OF THE COMPLEX COMPOUNDS OF RARE EARTH ELEMENTS WITH ARSENAZO AE. Akmaeva, N. L.; Dedkov, Yu. M.; Khramov, V. P. (Inst. of Geochemistry and Analytical Chemistry, Moscow. Inst. of Mechanization and Electrification of Agriculture, Saratov, USSR). Zh. Anal. Khim., 22: 1482-6(Oct. 1967). (In Russian).

Arsenazo AE (2-arsonobenzene-[1-azo-7]-1,8-dihydroxynaphthalene-3,6-disulfonic acid-[7-azo-1]-naphthalene-3,8-disulfonic acid) has been studied as a reagent for lanthanum, neodymium, praseodymium, samarium, gadolinium, ytterbium, erbium, and dysprosium. The composition of the complex compounds formed and their spectrophotometric characteristics have been established. The effects of some masking substances on the complexes of the reagent with the rare earth elements was also studied. (auth)

1994 SPECTROGRAPHIC ANALYSIS OF HIGH PURITY THORIUM. Degtyareva, O. F.; Sinitsyna, L. G. Zh. Anal. Khim., 22: 1500-5(Oct. 1967). (In Russian).

A method has been developed for the analysis of thorium metal and thorium compounds after they have been converted to ThO_2 for 36 element impurities with a sensitivity of 1×10^{-4} to 5×10^{-3}%. The analysis is carried out on the evaporator with brushes arranged at an angle to each other. The impurities are concentrated at 2300 to 2400°. The volatility of the impurities from ThO_2 has been studied within the range of 1100 to 2600°. High temperatures used for evaporating the impurities from ThO_2 permit the simultaneous determination of readily volatile elements as well as average and sparingly volatile elements. The condensate spectrum is excited in an ac arc by the current of 4.5 A. The exposure time is 50 sec. The spectrum is recorded simultaneously on two spectrographs. The mean square relative error is 7 to 20%. (auth)

1995 DIFFERENTIAL PHOTOMETRIC METHOD FOR DETERMINING TANTALUM WITH METHYL VIOLET. Dobkina, B. M.; Zubynina, K. A.; Malyutina, T. M.; Sazikova, G. B. (State Scientific-Research and Design Inst. of Rare Metal Industry, Moscow). Zh. Anal. Khim., 22: 1510-13(Oct. 1967). (In Russian).

A differential photometric method has been developed for determining tantalum with methyl violet. The suggested modification uses an imitating solution of copper ammine as a null solution. The method has been applied to the analysis of the industrial niobium pentoxide. (auth)

1996 DETERMINATION OF RHENIUM IN MOLYBDENITES AND COPPER ORES BY THE NEUTRON ACTIVATION METHOD. Minczewski, J.; Foldzinska, A. (Inst. of Nuclear Research, Warsaw). Zh. Anal. Khim., 22: 1514-18(Oct. 1967). (In Russian).

A radiochemical method for the determination of rhenium in molybdenites and copper ores, based on the extraction of the perrhenate-methylene blue complex with chloroform has been elaborated. The optimum conditions for the formation of the complex and its extraction has been established. The effects of molybdenum and tungsten on rhenium extraction has been examined. The method consists of a preliminary separation of molybdenum by ignition with CaO and $KMnO_4$, and extraction of the perrhenate-methylene blue complex with chloroform. Rhenium is then back extracted with 10% HCl and precipitated with thioacetamide as Re_2S_7. The determination of rhenium and the control of purity of the isolated rhenium sulfide is carried out by means of gamma spectrometry. The limit of the determination is 4×10^{-9} g of Re, for a neutron flux of 10^{12} neutrons/cm^2 · sec. A statistical evaluation showed the error of the determination to be ±20%. (auth)

1997 STUDIES ON ACTIVATION ANALYSIS WITH CHARGED PARTICLES. Chevarier, Noelle; Giroux, Jaxques; Tran Minh Duc; Tousset, Jean (Univ., Lyon). Bull. Soc. Chim. Fr., 8: 2893-8(Aug. 1967). (In French).

Activation-analysis methods with charged particles are summarized; a detailed comparative study was made between the "equivalent thicknesses" method of Engelmann and the method developed by Ricci et al. Irradiation facilities of the Lyon synchrocyclotron are described, and in particular a rabbit allowing irradiation in vacuum in the deflected beam. The counting of samples is started less than 50 sec after the end of the irradiation. A study by activation of α energy was performed using the relative variations of cross sections for the (α,xn) reactions on gold between 30 and 55 MeV. Considerations are given to recoil effects and parasitic reactions. (auth)

1998 DETERMINATION OF SOME COMPONENTS OF THE SOIL SOLUTION BY ION EXCHANGE-CHROMATOGRAPHY: NEUTRON ACTIVATION METHOD. Zmijewska, Wanda; Minczewski (Inst. of Nuclear Research, Warsaw). Chem. Anal. (Warsaw), 12: 675-81(1967).

Neutron activation was used for the determination of Na, K, Mn, Cu, Zn, Fe, and Co in soil solutions. The method consists of gamma-spectrometric measurement proceeded by radiochemical separation on ion exchange resins. The lower limits of determination were as follows: 0.0005 μg Mn; 0.001 μg Na, Co; 0.01 μg Zn; 0.1 μg K, and 0.5 μg Fe. The relative standard deviation varied from 2.3 to 19.0% depending on the element determined. (auth)

1999 COMPARISON OF THE RESULTS OF THE SPECTROGRAPHIC TRACE DETERMINATION IN URANIUM. Czakow, Julian; Cook, Gerald B.,; Kosta, Lado (IAEA Seibersdorf Lab., Austria). Chem. Anal. (Warsaw), 12: 687-96(1967).

A comparison of 680 spectrographic results (from 14 laboratories) from the analysis of identical samples of uranyl nitrate of nuclear purity to which known amounts of Bi, Cd, Co, Cu, Cr, Mn, Ni, and Fe was added, is presented. Detailed analytical data for these determinations are given, and the preparation of the sample as well as the reasons for the choice of given amounts of trace element additions are described. Analytical techniques used in this comparison are briefly described and the sources of possible error discussed. The normalized mean values for the respective elements, methods and Laboratories, as well as relative standard deviations are given. The contents of the trace elements in nuclear grade uranium (before spiking) were so small that they could not influence the reported results of analysis. It was found that relatively more results obtained with the use of preconcentration by extraction method in comparison to those from other techniques were present in the range of ±20% around the true value. This would suggest that preconcentration by extraction assures better accuracy. Best precision was obtained with the carrier distillation technique. It was concluded that the spectrographic methods in use yield sufficiently accurate and reproducible results and can be recommended for the use in routine laboratory analysis. (auth)

2000 CHELOMETRIC METHODS IN RAPID APPLIED ANALYSIS. XXVII. DETERMINATION OF ZIRCONIUM–YTTRIUM MIXTURES EMPLOYING EDTA. Pribil, R.; Horacek, J. (Heyrovsky Polarographic Inst., Czechoslovak Academy of Sciences, Prague). Chem.-Anal., 56: 76(Oct. 1967).

A chelometric procedure was developed that permits the determination of both zirconium and yttrium in the presence of each other. Zirconium is established by a back-titration at pH 1 to 2 of an excess of EDTA with bismuth using Xylenol Orange as indicator; after adjustment to pH 5.5, yttrium is determined by a direct EDTA titration. (M.C.G.)

2001 DETERMINATION OF RARE EARTHS IN PHOSPHATE ROCK BY ATOMIC ABSORPTION FLAME PHOTOMETRY. II. Kinnunen, J.; Lindsjo, O. (Pori Works, Finland). Chem.-Anal., 56: 76-8(Oct. 1967).

The determination of Sm, Gd, Dy, Yb, Tb, Ho, Er, La, and Pr in total rare earths from phosphate rocks by atomic-absorption flame photometry is reported. The most serious interferences in all determinations were caused by hydrofluoric acid, silica, and aluminum. (M.C.G.)

2002 PHOTOMETRIC DETERMINATION OF MOLYBDENUM EMPLOYING THIOSULFATE. Sarma, B. V. S.; Satyanarayana, D.;

Rao, V. Pandu Ranga (Andhra Univ., Waltair, India). Chem.-Anal., 56: 78-9(Oct. 1967).

A method for the determination of molybdenum was developed that involves the reaction of an acidified molybdate solution and thiosulfate, extraction of the lilac-to-red reaction product using 1-butanol–benzene, and photometric measurements. (M.C.G.)

2003 PHOTOMETRIC DETERMINATION OF MOLYBDENUM IN STEELS. Ambujavalli, S. (Dept. of Industries and Commerce, Madras). Chem.-Anal., 56: 79-80(Oct. 1967).

It was established that rapid separation using sodium peroxide–sodium hydroxide systems is applicable to the determination of molybdenum in steels using the photometric thiocyanate method. (M.C.G.)

2004 4'-AMINOACETOPHENONE IN THE SPOT TEST DETECTION OF CERIUM(IV). Somidevamma, G.; Sarma, M. S. (Andhra Univ., Waltair, India). Chem.-Anal., 56: 92(Oct. 1967).

4'-Aminoacetophenone, on reaction with cerium (IV) in acidic media, was found to yield a purple color that changes to a red-brown precipitate. The identification limit was found to be 1 μg and the dilution limit 1:50,000. Certain oxidants and palladium interfere in the test. (M.C.G.)

2005 DETERMINATION OF SMALL AMOUNTS OF ZIRCONIUM IN STEELS. Cechova, Drahomira (Skoda Worke, Pilsen, Czechoslovakia). Chem.-Anal., 56: 94-6(Oct. 1967).

Xylenol Orange was used for the photometric determination of zirconium in steels. For very small amounts of zirconium (0.002 to 0.05%) or with high-alloy steels, zirconium must first be separated. Relative errors of 18 and 4% were obtained for samples extremely low and high in zirconium, respectively. (M.C.G.)

2006 DETERMINATION OF GALLIUM IN MOLYBDO- AND TUNGSTOGALLATES VIA AN EDTA TITRATION. Rollins, Orville W.; Haynes, B. J. (U. S. Naval Academy, Annapolis). Chem.-Anal., 56: 98(Oct. 1967).

For determination of gallium in the presence of an excess of molybdate or tungstate a back-titration of EDTA with zinc using Eriochrome Black T as indicator was applied at pH 7.5. Use of a phosphate buffer appeared to mask the effects of molybdate and tungstate. In 19 titrations of 0.023 to 0.086 millimole of gallium taken as the heteropoly species, recoveries ranged from +0.0004 to −0.0005 millimole of theory. (M.C.G.)

2007 PHOTOMETRIC DETERMINATION OF INDIUM EMPLOYING CHROME AZUROL S. Sangal, Satendra P. (Univ. of Nagpur, India). Chem.-Anal., 56: 101(Oct. 1967).

Chrome Azurol S was used for the photometric determination of indium. For maximum color formation, a four-fold molar excess of the dye was necessary. Be, Sc, Y, La, rare earths, Th, Ti, Zr, Hf, Mo, W, U, Fe, Al, Ga, borate, carbonate, oxalate, and tartrate interfered even below 1 ppM. (M.C.G.)

2008 APPLICATION OF ISOTOPIC EXCHANGE FOR THE DETERMINATION OF TIN IN NICKEL. Csajka, M. (Central Research Inst. for Physics, Budapest). Talanta, 14: 1360-2 (Nov. 1967).

A method for determination of tin in nickel by activation analysis is described. Isotopic exchange is used for separation of tin from nickel. The most favorable conditions for the separation were determined, under which more than 99% of the tin can be recovered in 7 to 8 min. (auth) (UK)

2009 SPECTROPHOTOMETRIC INVESTIGATION OF ASCORBINATE COMPLEXES OF METALS. Stolyarov, K. P.; Amantova, I. A. (A. A. Zhdanov State Univ., Leningrad). Talanta, 14: 1237-44(Nov. 1967).

It was shown that ascorbic acid forms metal complexes of the types ML and MHL, depending on the pH used, and that these complexes are relatively unstable, especially those of type MHL. Their absorption spectra have no maxima, but have a steep slope at 320 to 380 mμ, and are displaced to longer wavelengths relative to the absorption spectrum of ascorbic acid. A bigger shift occurs for elements of variable valency, and the spectra move to longer wavelengths as the pH is raised; at pH 7 to 9 a maximum appears at 380 to 420 mμ, indicating a change of structure of the ascorbinate ion, probably with a lactone. Metals can be determined spectrophotometrically as their ascorbinates, at concentrations down to 10^{-5} M for Ti, U, Os, V, Cr, Nb, Ta, Zr, Mo, W, Sn, Pb, and Th, and 10^{-4} M for lanthanides, Sc, Hf, and Sb. (auth) (UK)

2010 X-RAY FLUORESCENCE WITH RADIONUCLIDES. Brunner, G. Isotopenpraxis, 3: 165-74(May 1967). (In German).

A bibliographic review is presented of studies on x-ray fluorescence with radionuclides. The equipment used, including radiation sources, samples, and detectors, is described. The sensitivity and measurement error of the method are examined. Uses of the method for quantitative determination of various elements are indicated. (115 references.) (J.S.R.)

2011 DETERMINATION OF ^{131}I IN WATER AND IN BIOLOGICAL MATERIALS BY DISTILLATION AND ANIONIC RESIN ABSORPTION. Franceschini, A.; Gandolfi, G. (SORIN, Saluggia, Italy). 23p. (In Italian). (CONF-650989-1). DTIE.

From Meeting of the Italian Association of Health Physics, Trieste, Italy.

A method for determination of ^{131}I in water and biological materials, which combines rapidity and simplicity of execution with efficient sensitivity to satisfy control requirements, is described. The method is based on the recovery of I liberated in the oxidation of the samples with sulfuric acid and potassium permanganate by condensation in a reflux coolant. The I released during the acid attack on the sample is distilled with carrier and absorbed on an anion resin. (J.S.R.)

2012 ANALITICHESKAYA KHIMIYA NIOBIYA I TANTALA. (Analytical Chemistry of Niobium and Tantalum). Gibalo, I. M. Analytical Chemistry of Elements. Moscow, Izdatel'stvo Nauka, 1967. 352p.

Chemical, physicochemical, and physical methods for the determination of Nb and Ta in various natural and technical objects are reviewed as well as the methods of determining impurities in metallic Nb and Ta and in their compounds. Separation of Nb and Ta from Ti, Zr, Mo, and W is discussed in detail. (1709 references) (R.V.J.)

2013 ANALYTICAL CHEMISTRY OF COBALT. Pyatnitskii, I. V. Analytical Chemistry of Elements. New York, Daniel Davey and Co., Inc., 1967. 237p. $14.00. (IPST-Cat.-2125).

Translated from Analiticheskaya Khimiya Kobal'ta by N. Kaner, Israel Program for Scientific Translations.

Topics covered include: chemical analytical characteristics of cobalt, cobalt compounds of importance in analytical chemistry, detection of cobalt ions, separation of cobalt from accompanying elements, gravimetric determination of cobalt, titrimetric methods for determination of cobalt, photometric methods for determination of cobalt, polarographic methods for determination of cobalt, and determination of cobalt in natural and industrial materials. (1533 references). (M.C.G.)

2014 CHELATES IN ANALYTICAL CHEMISTRY. A COLLECTION OF MONOGRAPHS. VOLUME I. Flaschka, H. A.; Barnard, A. J. Jr. (eds.). New York, Marcel Dekker, Inc., 1967. 427p. $18.75.

Topics covered include: history of analytical methods based on complex formation, Xylenol Orange and Methylthymol Blue as chromogenic reagents, chelating ion-exchange resins, conductometric and high-frequency impediment titrations involving chelates and chelating agents, thermal dissociation of chelating agents and chelates, fundamentals and applications of chelates in inorganic polarographic analysis, and chelates and chelating agents in the analytical chemistry of molybdenum and tungsten. (M.C.G.)

2015 ANALITICHESKAYA KHIMIYA REDKOZEMEL'NYKH ELEMENTOV I ITTRIYA. (Analytical Chemistry of Rare Earth Elements and Yttrium). Ryabchikov, D. I.; Ryabukhin, V. A. Analytical Chemistry of the Elements Series. Moscow, Izdatel'stvo Nauka, 1966. 381p.

The structure and most important properties of rare earth atoms, metals, and simple compounds are described. The most important natural sources of rare earth elements and separation of rare earth mixtures are discussed. Data on the analytical chemistry of the rare earths are divided among the following sections: qualitative reactions, methods of determination and separation, methods of quantitative determination, and analysis of basic groups. (2084 references). (J.S.R.)

Inorganic, Organic, and Physical Chemistry

Refer also to abstracts 1951, 2147, 2162, 2167, 2570, 2633, 2636, 2649, and 3177.

2016 (BAW-3714-4) GEL-ADDITION PROCESS CHEMICAL STUDIES. Quarterly Progress Report No. 4, April–June 1967. Dewell, E. H. (comp.) (Babcock and Wilcox Co., Lynchburg, Va. Research and Development Div.). Nov. 1967. Contract AT(30-1)-3714. 39p. Dep. CFSTI.

Development of the Gel-Addition Process for mixed urania-plutonia fuels was continued. UO_2 sols were prepared by the ORNL Formate Process. Gel spheres were made by drying sol droplets in a recirculating column containing a 2-ethylhexanol bath. Carbon analyses at various steps showed that at least half the carbon added (as urea and formate during sol preparation) remains in the sol. Gelation roughly tripled the carbon level (C/U atoms ratio in gel = 1.5). A study of the gelation bath composition showed that nitrated organics do not appear in sufficient quantity to constitute a hazard. Oxidation of Pu(IV) to Pu(VI) by nitrate was confirmed to be first order in Pu(IV). Apparent half-times were measured at 30 and 10 min. Plutonium pickup by UO_2 gel was found to be extremely rapid. In contacting runs lasting between 10 and 20 seconds, Pu/U + Pu reached several percent from Pu(IV) solutions. Ceramographic procedures were developed for polishing and photographing unfired gel. Most gel samples examined show cracking. Capsule design for in-pile testing of mixed oxide is complete. (auth)

2017 (BMI–1816) ANALYTICAL STUDIES OF METHYL IODIDE FORMATION UNDER NUCLEAR-REACTOR-ACCIDENT CONDITIONS. Barnes, Russell H.; McFarling, James L.; Kircher, John F.; Townley, Charles W. (Battelle Memorial Inst., Columbus, Ohio). Sept. 15, 1967. Contract W-7405-eng-92; Subcontract 2505. 58p. Dep. CFSTI.

For Oak Ridge National Lab., Tenn.

Homogeneous equilibrium studies based on typical steam and air systems where the total iodine concentration was varied from 4×10^{-12} to 4×10^{-6} g atom per liter and the total oxygen was varied over two orders of magnitude indicated that the high CH_3I concentrations sometimes observed experimentally are probably associated with nonequilibrium effects. Preliminary chemical-kinetic calculations indicated that concentrations higher than equilibrium would be expected for CH_3I formation on the basis of the reaction between CH_4 and I_2 where the presence of oxygen and its compounds is neglected. These preliminary calculations can reproduce the levels of CH_3I observed experimentally. Consideration is also given to the effects of radiation on CH_3I formation and an experimental program was initiated to obtain appropriate G-values for CH_3I formation from the reaction between CH_4 and I_2. (auth)

2018 (BMwF-FBK–67-76) FORTSCHRITTE IN DER VERGLEICHENDEN CHEMIE DER LANTHANIDEN- UND AKTINIDEN-ELEMENTE. Jahresbericht, 1965. (Comparative Chemistry of Lanthanide and Actinide Elements. Annual Progress Report, 1965). (Munich Univ. (West Germany). Institut fuer Anorganische Chemie). Aug. 1967. 27p. (In German). Dep.

Progress in the comparative chemistry of lanthanide and actinide elements is reported under the following topics: preparation of promethium metal and approximately 30 promethium compounds; crystal chemistry of promethium and its salts; vapor-phase hydrolysis of β-$DyCl_3$, γ-$DyCl_3$, $ErCl_3$, $TmCl_3$, YCl_3, and $PmCl_3$, and determination of the heats of formation of the corresponding oxyhalides; liquidus curve of UF_3–SmF_3; lattice constants of oxalate decahydrates $Ln_2(C_2O_4)_3 \cdot 10\ H_2O$, where Ln = Nd, Pm, Sm, from single crystal data; attempts to measure the vapor pressure of $PaCl_5$; mixed oxide studies in the systems of UO_2 with Ho_2O_3 and Yb_2O_3; emission spectra of Np, Pu, Am, Pm; and preliminary experiments in the crystal chemistry of radium. (auth)

2019 (BNL–50070) THE MECHANISMS OF OXIDATION-REDUCTION REACTIONS IN SOLUTION. Brookhaven Lecture Series Number 67. Sutin, Norman (Brookhaven National Lab., Upton, N. Y.). June 21, 1967. 8p. Dep. CFSTI.

The mechanisms of oxidation-reduction reactions in solution are discussed in terms of electron transfer processes, in particular, how the rates of electron transfer depend upon the structures of the substances undergoing oxidation and reduction. It is shown that the oxidation-reduction reaction proceeds in a number of steps, and an attempt is made to describe the detailed arrangement of the atoms in each of these steps. Special attention is given to oxidation-reduction reactions involving metal ions. Two types of reactions are described: the first consists of reactions called outer-sphere reactions, in which no bonds are formed or broken, and the second is one in which the reaction proceeds via an inner-sphere mechanism. In these reactions a bridging group is directly bonded to both metal centers. (P.C.H.)

2020 (CEA-Blb-93) CROISSANCE DES CRISTAUX METALLIQUES PAR DECOMPOSITION THERMIQUE DES HALOGENURES EN PHASE GAZEUSE. (Growth of Metallic Crystals by Thermal Decomposition of Halides in the Gas Phase). Gillardeau, Jacques (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Sept. 1967. 24p. (In French). Dep.

Various results published on the growth of metallic crystals by the thermal decomposition of gaseous halides were obtained mainly with iodides. The experimental techniques used are described together with the various factors affecting the efficiency of metal deposition produced by this thermal decomposition. (auth)

2021 (CEA-R-3218) SUR LA STOECHIOMETRIE DE L'OXYDE $U_3O_{(8\pm x)}$: INFLUENCE DE LA TEMPERATURE ET DE LA PRESSION. (Nonstoichiometry in $U_3O_{(8\pm x)}$: Its Temperature and Oxygen Pressure Dependence). Rodriguez de Sastre, Maria-Sara; Philippot, Joseph; Moreau, Claude (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). May 1967. 10p. (In French). Dep.

The deviation from stoichiometry in uranium oxide U_3O_8, obtained by oxidation of UO_2, was studied with respect to its dependence on temperature and oxygen pressure. It is shown that the ratio r = O/U increases with oxygen pressure up to 200 mm Hg at any temperature. At higher pressures, this ratio tends toward a limit that decreases with increasing temperatures. The curve r = f(P) suggests a chemisorption phenomenon as the reaction-limiting mechanism. (auth)

2022 (COO–1142-77) PROGRESS REPORT [ON ISOTOPIC KINETICS], OCTOBER 1, 1966–SEPTEMBER 30, 1967. Yankwich, Peter E. (Illinois Univ., Urbana). Oct. 20, 1967. Contract AT(11-1)-1142. 25p. Dep. CFSTI.

Developments are reported for studies on: carbon isotope effects in decomposition of oxalic acid in glycerol; anomalous temperature dependence of kinetic carbon isotope effects; autocatalysis and deuterium isotope effects in reactions of formic acid and NO_2; carbon isotope effects in metal-ion oxidations of formic acid; ^{13}C isotope effects in structural isomerization of cyclopropane; temperature dependence of ^{13}C isotope effect in decarboxylation of malonic acid vapor; ^{13}C isotope effects in decomposition of hydrogen malonate ion in dioxane; intramolecular ^{13}C isotope effect in decomposition of oxalic acid in dioxane; kinetic, isotope, and stoichiometric effects in pyrolysis of manganous oxalate; flash photolysis of formic acid vapor; theoretical calculation of kinetic isotope effects, anomalous temperature dependence, and variations of reaction coordinate. (P.C.H.)

2023 (COO–1147-22) PHYSICAL CHEMISTRY OF HIGHLY ENERGETIC SYSTEMS. Technical Progress Report, February 1967 to February 1968. Stafford, F. E. (Northwestern Univ., Evanston, Ill. Dept. of Chemistry). Oct. 30, 1967. Contract AT(11-1)-1147. 3p. Dep. CFSTI.

Developments are reported for studies on: absolute ionization cross section of Ag; relative cross sections of transition elements; and reactions of hydrogen with boron and/or carbon at 2000°C. (P.C.H.)

2024 (CU–2791-6(App.)) FLOW-REACTOR KINETICS OF ETHYLENE HYDROGENATION OVER METAL OXIDE CATALYSTS. Kyi, Roland Ru-kwei (Columbia Univ., New York). 1966. 93p. Dep. CFSTI.

Thesis.

The kinetics of ethylene hydrogenation over metal oxide catalysts, TiO_2, Cr_2O_3, Fe_2O_3, and ZnO, were investigated in a flow reactor, at temperatures between 90 and 475°C and a total pressure of 1 atmosphere. The activation energy and the reaction order were determined using helium as a diluent. The rate of hydrogenation to ethane was found to be less than first-order in ethylene partial pressure over all the catalysts and first-order in hydrogen partial pressure over TiO_2, Cr_2O_3, and Fe_2O_3 but second-order in hydrogen partial pressure over ZnO. The apparent activation energy was found to be 22 kcal/mole for TiO_2 around 400°C, 19 kcal/mole for Cr_2O_3 around 250°C, 23 kcal/mole for Fe_2O_3 around 100°C, and 62 kcal/mole for ZnO around 320°C, which changed to 34 kcal/mole at temperatures above about 360°C. A possible explanation of the reaction mechanism is offered. (auth)

2025 (EUR–3641d) UNTERSUCHUNGEN UEBER DIE CHEMISCHEN UND PHYSIKALISCHEN EIGENSCHAFTEN DES ELEMENTS TECHNETIUM. SCHLUSSBERICHT 1.11.1964–31.10.1966. (Examination of the Chemical and Physical Properties of the Element Technetium. Final Report, November 1, 1964–October 31, 1966). (Kernforschungsanlage, Juelich (West Germany)). Nov. 1967. Contract 064-64-10 RISD. 34p. (In German). Dep.

The diffusion coefficient of the TcO_4 ion for 25°C was calculated on the basis of conductivity measurements in $KTcO_4$ solutions as being $D_0 = 1.48 \times 10^{-5}\ cm^2 \cdot sec^{-1}$. The self-diffusion coefficients of the pertechnetate ion in the presence of basic electrolytes could be determined only by the capillary method. For 10^{-3} m TcO_4 the results were $D = 1.27 \times 10^{-5}$ at 25°C in a 1 M sodium lye solution and $D = 1.24 \times 10^{-5}\ cm^2 \cdot sec^{-1}$ in a 1 M LiCl solution. After direct-current polarographic measurements, four reduction stages of TcO_4 with half-stage potentials at −0.8 V, −1.1 V, −1.6 V and −1.7 V occurred in alkaline basic electrolytes. The electron transfers $n \simeq 2$, corresponding to Tc(VII) → Tc(V) and $n \simeq 3$, corresponding to Tc(VII) → Tc(IV) could be associated with the propor-

tional concentration stages at −0.8 and −1.1 V. Stages 3 and 4 were of a catalytic nature. From an alternating-current polarographic standpoint, four waves could be ascertained. The reversibility measurement for the first wave at −0.8 V gave alternating current yields from 70 to 90% depending on the nature and concentration of the basic electrolytes. The underlying electrode process in the case of the second wave was also to all intents and purposes reversible. For quantitative direct- or alternating-current polarographic determination of TcO_4^-, the first reduction stage or wave was suitable in a neutral as well as in an alkaline solution. Technetium can be detected polarographically in the presence of ReO_4^- and any MoO_4^{2-} surplus. Two waves appear at −0.33 and −0.20 V in inverse polarography. Up to 3×10^{-7} mole l^{-1} TcO_4^- proportionality between peak current and concentration was recorded for the first wave. (auth)

2026 (FOA-2-2496-44) SYNPUNKTER PA TILLSTAND-SEKVATIONEN FOER URANDIOXID. (Points of View on the Equation of State of Uranium Dioxide). Gylden, N. (Forsvarets Forskningsanstalt, Stockholm (Sweden)). Sept. 1967. 14p. (In Swedish). Dep.

The equation of state of UO_2 is discussed for densities approximately equal to 10 g/cm³ and at temperatures of about 2×10^4°K. The application of the principle of corresponding states and the Mie-Grueneisen equation of state for metals is compared. Since the density is 3 times greater than the critical density of UO_2 use of the corresponding state principle is doubtful. Instead the Mie-Grueneisen equation with regard to the melting process is recommended. (Sweden)

2027 (IA-1136) INFRARED STUDIES OF ANTIFERROELECTRIC $NH_4H_2PO_4$ TYPE CRYSTALS. Wiener (Avnear), E.; Levin, S.; Pelah, I. (Israel Atomic Energy Commission, Yavne. Soreq Nuclear Research Center). Aug. 1967. 20p. Dep.

The antiferroelectric phase transition in $NH_4H_2PO_4$ was studied by measuring the infrared absorption spectra (250 to 4000 cm^{-1}) in both phases. The changes in the spectrum occurring on crossing T_c were compared with those found earlier in the ferroelectric transition of KH_2PO_4. The appearance of more lines in the antipolar phase led to the conclusion that in this phase the hydrogens are arranged asymmetrically along the c axis, thus inducing an antiparallel dipole arrangement. The infrared absorption spectrum of a mixed crystal $NH_4H_2PO_4$: $NH_4H_2AsO_4$ was measured at different temperatures in order to test the validity of the site group assignments in these crystals. Prominent changes were observed in the spectra of $ND_4D_2PO_4$, $NH_4H_2AsO_4$, and $ND_4D_2AsO_4$ on crossing the antiferroelectric Curie point. (auth)

2028 (IFA-IS-48) ISOTOPIC EXCHANGE OF DEUTERIUM BETWEEN HYDROGEN AND WATER VAPOR ON ALUMINA PROMOTED NICKEL. Olariu, Al.; Marginean, P. (Academia R. P. R., Bucharest. Institutul de Fizica Atomica). Sept. 11, 1967. 10p. Dep.

Measurement of nickel surface area, catalytic activity, and total surface area of alumina-promoted nickel was carried out. As a test reaction of the catalytic activity the isotopic exchange of deuterium between hydrogen and water vapor was used. The experimental results were compared with those previously obtained for chromia-promoted nickel. The better dispersed alumina-promoted nickel was less active than chromia-promoted nickel. The role of promoter nature is discussed. (auth)

2029 (JINR-P12-3529) OPREDELENIE USTOICHIVOSTI KHLORIDNYKH KOMPLEKSOV ODNOVALENTNOGO KATIONA ASTATA V AZOTNOKISLYKH RASTVORAKH. (Determination of the Stability of the Chlorine Complexes of a Monovalent Astatine Cation in the Nitrate Solutions). Norseev, Yu. V.; Khalkin, V. A. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1967. 11p. (In Russian). Dep.

Using the cation exchange resin Dowex 50 × 8 it was shown that a monovalent positive astatine ion produces, in 0.5 M HNP_3 − 5×10^{-3} M $H_2Cr_2O_7$ − $(4 \pm 2) \times 10^{-3}$ M HCl solutions, chlorine complexes with one and two ligands. The values of stability constants for these complexes were found to be $\beta_1 = 7 \times 10^3$ M^{-1} and $\beta_2 = 2.5 \times 10^5$ M^{-2}. (auth)

2030 (NYO-3783-3) PROGRESS REPORT [ON DEUTERIUM SEPARATION], JANUARY 1, 1967–October 1, 1967. White, David (Pennsylvania Univ., Philadelphia. Dept. of Chemistry). Contract AT(30-1)-3783. 13p. Dep. CFSTI.

A scheme was considered to improve the efficiency of ortho-para separations. This consisted of utilizing a single long column that is initially equilibrated with normal hydrogen or deuterium at liquid hydrogen temperatures. One end of the column is then shut off and the hydrogen or deuterium is then progressively desorbed from the closed end to the open end. For column diameters of approximately one inch and lengths of the order of 3 feet it is possible to achieve approximately 20 theoretical plates for 2 to 3 liters. The measured values of the integral ortho-para separation factor of deuterium on γ-alumina adsorbent at 20°K was 1.8 ± 0.2 whereas that for hydrogen was 3.0 ± 0.2. Cryogenic equipment required for pulsed nuclear magnetic resonance experiments was fabricated and installed. Measured vapor pressure differences between deuterium of a given para concentration and equilibrium deuterium as a function of temperature are shown. The phase transformation in solid deuterium was studied. (auth)

2031 (ORNL-IIC-10(Vol.1), pp 130-41) IDENTIFICATION OF MOLECULAR STRUCTURES BY THE MOESSBAUER EFFECT: FERROCENE ADSORPTION ON HIGH SURFACE AREA SILICA, ALUMINA, AND SILICA ALUMINA. Cook, C. F.; Gray, P. R.; Barton, H. M. Jr. (Phillips Petroleum Co., Bartlesville, Okla).

Mössbauer spectroscopy was applied to the identification of molecular structures resulting from the impregnation of ferrocene on high-surface-area gels such as silica. Ferrocene-impregnated silica was heated to various temperatures in an inert atmosphere and cooled prior to obtaining the Mössbauer spectra. Physical adsorption of ferrocene was identified before heating. Heating in the range from 150 to 475°C formed a ferric silicate complex. Further heating converted the surface complex to a ferrous silicate at temperatures of 475 to 600°C. Above 600°C, a second ferrous silicate, which was identified as Fe_2SiO_4, formed. Similar results were obtained with the following derivatives of ferrocene impregnated on silica: acetylferrocene, diacetylferrocene, 1-hydroxyethylferrocene, vinyl ferrocene, ferrocenemonocarboxylic acid, and ferrocenedicarboxylic acid. Results obtained using ferrocene impregnation of silica-alumina and three different aluminas are also given. Mass spectrometric analyses of the gases evolved during decomposition of the ferrocene on silica indicate that all of the hydrocarbon from the ferrocene was removed during the formation of the ferric complex. (auth)

2032 (ORNL-TM-2036) REDUCTION OF IRON DISSOLVED IN MOLTEN LiF-ThF_4. Barton, C. J.; Stone, H. H. (Oak Ridge National Lab., Tenn.). Nov. 2, 1967. Contract W-7405-eng-26. 15p. Dep. CFSTI.

Additions of ^{59}Fe tracer to LiF − ThF_4 (73 to 27 mole %) permitted rapid and sensitive measurements of the iron content of filtered samples of molten material. More than 40 hours were required for nearly complete removal of iron from the melt by hydrogen reduction at about 600°C while reduction of iron by metallic thorium at the same temperature was virtually complete after three hours. Disappearance of a relatively large quantity of solid thorium on long exposure to the molten salt will require further investigation. Comparison of the data obtained by use of ^{59}Fe tracer counts with the results of colorimetric iron determinations by two different laboratories seemed to indicate that the colorimetric iron method employed when these tests were performed did not give reliable iron results at low iron concentrations. Colorimetric nickel determinations by the two laboratories gave divergent data for more than half of the samples. (auth)

2033 (ORO-3621-6) CHELATION AND OLATION REACTIONS OF METAL IONS IN AQUEOUS SOLUTION. Progress Report, January 1–September 30, 1967. Martell, Arthur E. (Texas Agricultural and Mechanical Univ., College Station. Dept. of Chemistry). Oct. 16, 1967. Contract AT(40-1)-3621. 5p. Dep. CFSTI.

A precise microcalorimeter was set up, together with a constant-temperature control system. It is being checked out with metal chelates having known heats of formation. Research is being carried out to determine the nature of the bonding between multidentate ligands and metal ions of high ionic charge and high coordination number. Hydrolysis and olation of thorium complexes are being studied. (M.C.G.)

2034 (RISO-153) INVESTIGATIONS ON METHODS OF PRODUCING CRYSTALLINE AMMONIUM-URANYL CARBONATE AND ITS APPLICABILITY FOR PRODUCTION OF URANIUM-DIOXIDE POWDER AND PELLETS. Jensen, Margrethe (Danish Atomic Energy Commission, Risoe. Research Establishment). May 1967. 32p. Dep. CFSTI.

A method for the production of crystalline ammonium uranyl carbonate is described. Because of its simple synthesis and its chemical composition, this substance is a suitable intermediate product in the making of uranium dioxide powder for reactor fuel. Experimental data for the precipitation of ammonium uranyl carbonate are presented. The density and dimensions of the uranium dioxide pellets made from the precipitate are indicated and the results are evaluated. (auth) (Denmark)

2035 (UCRL-17858) THE VISCOSITY OF CONCENTRATED SOLUTIONS OF CALCIUM IN LIQUID AMMONIA IN THE TEMPERATURE INTERVAL OF -40°C TO -70°C. Earhart, Jonathan P. (California Univ., Berkeley. Lawrence Radiation Lab.). Oct. 1967. Contract W-7405-eng-48. 55p. Dep. CFSTI.

Thesis.

The viscosity of concentrated solutions of calcium in liquid ammonia was determined in the concentration interval from 3.4 to 8.9 mole % calcium at temperatures from −40 to −70°C. The modified cross-arm viscometer used for the measurements was calibrated at each of the temperatures at which measurements were made. A minor surface tension correction was made using the surface tension of sodium-ammonia solutions in the absence of such data for calcium-ammonia solutions. An analysis of possible errors indicated that the results are accurate to ±5%. The viscosity of concentrated solutions at concentrations near the two phase region (about 40% of saturation) are nearly equal to the viscosity of pure liquid ammonia at the same temperature. At −40°C a solution with a concentration of 8.9 mole % calcium (83% of saturation) has a viscosity more than twice that of the pure solvent. Similar increases in viscosity with increasing concentration were found at all temperatures between −40 and −70°C. This is the opposite of the effect in sodium- and potassium-ammonia solutions where the viscosity decreases with increasing concentration. A possible explanation for these results is offered. (auth)

2036 DISSOLUTION REACTION OF U_3O_8 IN SULFURIC ACID. II. VARIATION IN OXIDE COMPOSITION DURING DISSOLUTION. Solntsev, V. M.; Tolmachev, Yu. M. Radiokhimiya, 9: 330-5(1967). (In Russian).

The change of state of the oxide during dissolution of U_3O_8 was found to be a reversible process. The dependence of the state of the oxide obtained on dissolution conditions was established experimentally. The thermodynamic criteria of congruent and incongruent dissolution of the oxide were obtained. (tr-auth)

2037 CEMENTATION OF EUROPIUM WITH SODIUM AMALGAM. Gladyshev, V. P.; Enikeev, R. Sh., Nauryzbaev, M. K. Radiokhimiya, 9: 360-5(1967). (In Russian).

Studies were made on the influence of various factors on the kinetics of cementation of europium from aqueous solutions with sodium amalgam. The factors studied were: stirring rate, temperature, buffer content of the medium, and presence of surface-active anions capable of accelerating the discharge of multivalent cations. A technique combining polarography and radiochemical analysis was employed. It was found that when the amalgam reaches a potential of −1.8 V, the cementation process ceases, and europium begins to migrate from the amalgam into the solution $Eu(Hg) + 2H^+ \rightarrow Eu^{2+} + H_2$. Divalent europium ions are formed in the solution mainly as a result of decomposition of the europium amalgam according to the reaction $Eu(Hg) + 2H^+ \rightarrow Eu^{2+} + H_2$, and not as an intermediate product of the reduction of trivalent europium ions by sodium amalgam. Hence, the content of Eu^{2+} ions can serve as a quantitative measure of excess time of contact between the amalgam and the solution. An increase in temperature and stirring rate were found to lower the extraction of europium during cementation because of the increased decomposition rate of europium amalgam. It is shown that surface-active anions increase the rate of cementation of europium by sodium amalgam in the series $Cl^- < Br^- < CNS^- < I$. (ATD)

2038 DIRECTED CRYSTALLIZATION OF AQUEOUS SOLUTIONS OF URANYL NITRATE AND SODIUM NITRATE. Kirgintsev, A. N.; Gvozdev, B. A.; Zakhvataev, B. B. Radiokhimiya, 9: 371-4(1967). (In Russian).

Aqueous solutions of uranyl nitrate and sodium nitrate of cryotectic concentration and solutions of one-half this concentration were subjected to directed crystallization. Microquantities of americium or plutonium (10^{-6} to 10^{-7} g/liter) were introduced into the solutions. A study of the directed crystallization at v = 0.5 cm/hr showed the distribution of americium and plutonium after the crystallization to be very close to uniform distribution. The distribution coefficeint was found to be ~0.95 in all cases. Americium behaves in approximately the same manner in both uranyl nitrate and sodium nitrate solutions, but plutonium is trapped to a much greater degree during the directed crystallization of uranyl nitrate than during that of sodium nitrate solutions. Ice and salt are formed by the crystallization, and it was found that ice traps much more americium than plutonium. (ATD)

2039 SOLUBILITY OF URANIUM TETRAFLUORIDE IN AN ALUMINUM SALT SOLUTION. Vdovenko, V. M.; Romanov, G. A. Radiokhimiya, 9: 384-6(1967). (In Russian).

From the basic data on the solubility of UF_4 in $Al(ClO_4)_3$ solutions and of the absorption spectra of these solutions it was concluded that in the system studied U(IV) occurs in the form of the complex ion UF_3^{3+}. The solubility of UF_4 in solutions containing hydrated ions of tetravalent U was investigated. It was found that in the solution of UF_4 the complex UF_3^{3+} was formed. (tr-auth)

2040 PREPARATION OF XENON DIFLUORIDE LABELED BY RADIOACTIVE XENON. Kirin, I. S.; Tikhonov, V. I. Radiokhimiya, 9: 395(1967). (In Russian).

A method for the preparation of xenon difluoride under static conditions is described. The glass apparatus for the preparation is sketched. (J.S.R.)

2041 INFLUENCE OF THE SOLID PHASE RADIOACTIVITY ON THE KINETICS OF HETEROGENEOUS ISOTOPIC EXCHANGE. Gromov, V. V.; Bekman, I. N.; Spitsyn, Vikt. I. Radiokhimiya, 9: 296-304(1967). (In Russian).

In the system K_2SO_4(crystal) − K_2SO_4(solution) the effects of the specific radioactivity of the solid phase at different temperatures on the velocity of the heterogeneous isotopic exchange was studied. It was established that the exchange process occurs in two stages-surface and internal, both of which proceed with constant velocity, but the internal exchange is ten times slower than the surface exchange. With increase of the specific radioactivity of the solid phase the velocity of both stages of the exchange process increased. However the velocity of the internal exchange increased to a greater degree than that of the surface exchange. It was suggested that the equilibrium defects of the crystalline lattice, caused during the radioactive decay of the constituents affect the kinetics of the heterogeneous isotopic exchange. (tr-auth)

2042 THEORETICAL AND EXPERIMENTAL STUDIES OF IR ABSORPTION SPECTRA OF COMPLEX URANYL COMPOUNDS WITH A TETRAGONAL BASIS IN THE EQUATORIAL PLANE. Kharitonov, Yu. Ya.; Knyazeva, N. A.; Tsapkin, V. V.; Ellert, G. V. Radiokhimiya, 9: 322-30(1967). (In Russian).

A theoretical analysis was made of the oscillation of the model of uranyl complexes with tetragonal basis in the equatorial plane. Results of studies for the interpretation of the spectra of uranyl halogenide complexes are reported. (tr-auth)

2043 SORPTION OF METAL COMPLEXES ON SILICA GEL. III. SORPTION OF THE HYDROLYTIC PRODUCTS OF Th^{4+}, Fe^{3+}, Al^{3+}, AND Cr^{3+}. Vydra, F.; Galba, J. (Polarography Inst. J. Heyrovsky, Prague. Agricultural Coll., Nitra, Czechoslovakia). Collect. Czech. Chem. Commun., 32: 3530-6(Oct. 1967). (In German).

The sorption of Th^{4+}, Fe^{3+}, Al^{3+}, and Cr^{3+} on silica gel was investigated under static conditions at pH values at which these metal ions form colloidal hydroxides. The influence of the pH value and the amount of hydrogen ions on the sorption of the hydrolytic products of the metal ions was determined and the probable sorption mechanism postulated. (tr-auth)

2044 MECHANISMS OF ELIMINATION REACTIONS. THE EFFECT OF ADDED DIMETHYL SULPHOXIDE ON RATES, ISOTOPE EFFECTS, AND SUBSTITUENT EFFECTS IN THE REACTION OF 2-ARYLETHYLDIMETHYLSULPHONIUM BROMIDES WITH SODIUM HYDROXIDE IN WATER. Cockerill, Anthony F. (Univ. of Essex, Colchester, Eng.). J. Chem. Soc., B, No. 10, 964-9(1967).

Rates of elimination were determined for the reactions of 2-arylethyldimethylsulphonium bromides with sodium hydroxide in water containing from 0 to 85 mole % of dimethyl sulphoxide. Kinetic deuterium isotope effects (k_H/k_D) were determined using dimethyl-2-phenylethylsulphonium bromide and its 2,2-dideuterioisomer. Hammett reaction constants (ρ) were determined with the p-substituents methoxy, methyl, hydrogen, and chlorine. The values of k_H/k_D and ρ were used, in conjunction with the sulphur isotope effects previously measured, to assess the influence of solvent composition on the E2 transition state. As the solvent was gradually enriched in dimethyl sulphoxide, the ρ value increased sharply and then remained almost constant, while k_H/k_D rose from the value reported in water, passed through a maximum, and then decreased. In going from water to 85% dimethyl sulphoxide, the rate increased by 10^7, and rates measured in the range 30 to 60°C indicated a large reduction in both the enthalpy and the entropy of activation as the medium was made less aqueous. It is suggested that dimethyl sulphoxide induces a more "reactant-like" transition state than is encountered in the elimination reaction in water. (auth) (UK)

2045 CORRELATION OF ISOTOPE EFFECTS IN SUBSTITUTION REACTIONS WITH NUCLEOPHILICITIES. SECONDARY α-DEUTERIUM ISOTOPE EFFECT IN THE ^{131}I EXCHANGE OF METHYL-d_3 IODIDE. Seltzer, S.; Zavitsas, A. (Brookhaven National Lab., Upton, N. Y.). Contract AT(30-2)-Gen-16 Can. J. Chem., 45: 2023-32(Sept. 1967). (BNL-10997).

The secondary α-deuterium isotope effect in ^{131}I exchange between sodium iodide and methyl-d_3 iodide is $k_H/k_D = 1.05 \pm 0.01$ in methanol and 1.10 ± 0.04 in water at 20°C. A correlation of secondary α-deuterium and ^{13}C effects, in bimolecular nucleophilic substitution reactions, with the difference of E values between nucleophile and leaving group is presented. (auth) (CANADA)

2046 MASS SPECTROMETRIC STUDIES AT HIGH TEMPERATURES. XXV. VAPOR COMPOSITION OVER $LaCl_3$, $EuCl_3$, AND $LuCl_3$ AND STABILITIES OF THE TRICHLORIDE DIMERS. Hastie, J. W.; Ficalora, P.; Margrave, J. L. (Rice Univ., Houston, Tex.). J. Less-Common Metals, 14: 83-91 (1968). (ORO-2907-21).

Mass spectrometric studies of the vapors over $LaCl_3(s)$, $EuCl_3(s)$, $EuCl_2(l)$, and the mixture $EuCl_3 + LuCl_3$ indicate the existence of dimers in small amount (1%) at pressures of less than 0.1 mm. However, the data predict dimers to be a more dominant species at temperatures approaching the boiling point. Ion current vs temperature data yield heats of vaporization or sublimation that are in good agreement with previous results as well as values for the heats of dimerization. With absolute pressure data, the entropy for the reaction $2LaCl_3(g) = La_2Cl_6(g)$ was calculated to be $\Delta S^{\circ}_{1000°K} = -30.0 \pm 3.0$ eu/mole of dimer. The proportion of dimer to monomer, as indicated by the heats of dimerization, varies considerably with the nature of the metal. No dimerization or significant disproportionation of $EuCl_2(g)$ was found. (auth)

2047 THE s,t DOUBLET IN L-SPECTRUM OF ^{67}Ho. Nigam, A. N.; Kapoor, Q. S. (Univ. of Rajasthan, Jaipur, India). Naturwissenschaften, 54: 560(Nov. 1967).

The presence of s and t lines at 1953.5 and 2011.4 x.u., respectively, in the L-spectrum of holmium is reported. The measurements are in fair agreement in values calculated from energy levels and fit nicely in the Moseley plot. (M.C.G.)

2048 LUMINESCENCE SPECTRA OF URANYL HYDROXO COMPLEXES IN SOLUTION. Baran, V.; Tympl, M. (Inst. of Nuclear Research, Czechoslovak Academy of Sciences, Rez). Collect. Czech. Chem. Commun., 32: 3625-45(Oct. 1967).

The luminescence spectra of uranyl hydroxo complexes were measured in solutions alkalized to different extents up to the precipitation of uranium from the solution. Both the intensities and energies of individual emission bands were studied. From the intensities it was concluded that the complexes $[UO_2(OH)_2UO_2]^{2+}$ are the sources of luminescence; if there are other ligands bound to these complexes, quenching is caused to a larger or smaller extent. Changes in luminescence properties of the liquid phase of heterogeneous systems with alkalization cannot be fully explained. From energies of the emission bands it follows that the linear harmonic oscillator as a physical model cannot be used for explanation of the properties found, because the energy of the symmetric vibrations of uranyl increases with the vibrational quantum number. The values of pure electron transitions are practically the same for all measured hydroxo complexes, which suggests that their structure is essentially the same. The behavior of uranyl hydroxo complexes in the absorption of the visible radiation does not reveal any analogy with their behavior in its emission. (auth)

2049 PROTONATION OF THE INDOLE GRIGNARD REAGENT AND OTHER ORGANOMETALLIC DERIVATIVES OF INDOLE. Powers, James C.; Meyer, William P.; Parsons, Thomas G. (Univ. of California, Los Angeles). J. Amer. Chem. Soc., 89: 5812-20(Nov. 8, 1967).

Alkali metal derivatives of indole protonated predominantly on nitrogen. The Grignard reagent on the other hand gave carbon protonation when intermediate amounts of D_2O were added. Addition of very large or very small amounts of D_2O yielded either N-protonation or no reaction followed by N-protonation in the work-up. The effects of concentration, solvent, and heterogeneity on the amount of carbon protonation of the indole Grignard reagent are described. The results are discussed in terms of the structure of the organometallic derivatives of indole and the mechanism of their protonation. (auth)

2050 REACTIONS OF CYTOSINE DERIVATIVES WITH ACIDIC BUFFER SOLUTIONS. II. STUDIES ON TRANSAMINATION, DEAMINATION, AND DEUTERIUM EXCHANGE. Shapiro, Robert; Klein, Robert S. (New York Univ.). Biochemistry, 6: 3576-82(Nov. 1967).

Cytidine reacts with certain aromatic amines in aqueous solution at pH 4 to give transamination to N_4-arylcytidines and deamination to uridine. The transamination products of cytidine with aniline, o-aminophenol, and β-naphthylamine were isolated and characterized. Aniline reacts more slowly than p-aminophenol, and α-naphthylamine gives only trace amounts of transamination products. These results are discussed with reference to the known carcinogenic properties of aromatic amines. Studies were continued on the previously reported deamination of cytidine by carboxylate buffers. The use of a 0.5 M solution of mellitic acid, titrated with pyridine to pH 5, is recommended as suitable for synthetic or mutagenic purposes. It was noted that H_5 of cytidine exchanges for deuterium when cytidine is heated in D_2O in acidic citrate buffers. Deuterium exchange is more rapid than deamination. This is interpreted in terms of a common addition–elimination mechanism for both deuterium exchange and deamination. (auth)

2051 NOR STEROIDS. VI. KINETIC STUDIES ON THE FAVORSKII REARRANGEMENT. Nace, Harold R.; Olsen, Barbara Ann (Brown Univ., Providence). J. Org. Chem., 32: 3438-42(Nov. 1967).

2α-Chloro-, bromo-, and iodocholestan-3-one were prepared and subjected to Favorskii rearrangement conditions. Product analyses were performed and the rates of the reactions were determined. They showed that the order of reactivity was iodo > bromo > chloro. The corresponding deuterated halides were prepared. The rates of their reactions showed a primary deuterium isotope effect, indicating that loss of a proton was involved in the rate-determining step. Interruption experiments on the deuterated halides showed that the hydrogen on the halogen-carrying carbon was rapidly lost prior to the rearrangement reaction. (auth)

2052 ENOLIZATION OF KETONES. III. THE RATE AND ORIENTATION OF ACID-CATALYZED DEUTERATION OF SOME METHYL KETONES. Rappe, Christoffer; Sachs, William H. (Uppsala Univ.). J. Org. Chem., 32: 3700-3(Nov. 1967).

The deuteration of a number of methyl ketones was studied by NMR spectroscopy. When first-order plots of the data were made, straight lines were obtained up to about 40% deuteration. Examining the pseudo-first-order rate constants of the ketones, it seems to be a general feature that a large and bulky group increases the rate of methyl deuteration. The methylene group of an unbranched methyl ketone deuterated faster than the methyl group. The methylene group of 2-butanone deuterated about 20 to 30% faster than the methylene groups of the higher homologs. The reason for the slower rate of the methylene deuteration in 4-methyl- and 4,4-dimethyl-2-pentanone seems to be found in the increased steric interaction arising from the isopropyl and t-butyl groups. The investigation showed a pronounced discrepancy between orientation of deuteration and the accepted rules for the acid-catalyzed enolization of ketones. This discrepancy is discussed. (D.H.M.)

2053 FLUORINE BOMB CALORIMETRY. ENTHALPIES OF FORMATION OF THE DIBORIDES OF NIOBIUM AND TANTALUM. Johnson, Gerald K.; Greenberg, Elliott; Margrave, John L.; Hubbard, Ward N. (Argonne National Lab., Ill. Univ. of Wisconsin, Madison). J. Chem. Eng. Data, 12: 597-600(Oct. 1967).

The energies of combustion in fluorine of nonstoichiometric specimens of the diborides of niobium and tantalum were measured in a bomb calorimeter. The standard enthalpies of formation, $\Delta H^{\circ}_{298.15}$, were -58 ± 1 and -43 ± 1 kcal $(gfm)^{-1}$ for $NbB_{1.875 \pm 0.005}$ and $TaB_{1.910 \pm 0.004}$, respectively. (auth)

2054 ORGANIC COMPOUNDS OF URANIUM. III. REACTIONS OF URANIUM PENTA-ALKOXIDES WITH ACETYL CHLORIDE. Bhandari, A. M.; Kapoor, R. N. (Univ. of Jodhpur, India). J. Chem. Soc., A, No. 10, 1618-19(1967).

Reactions of uranium penta-alkoxides with acetyl chloride give high yields of the compounds $U(OR)_{5-n}Cl_n$ (R = Et and Pr^i, n = 1 to 3; R = t-C_5H_{11}, n = 1) and the adducts $U(OR)Cl_4$, $MeCO_2R$ (R = Et and Pr^i). (auth) (UK)

2055 PROTACTINIUM(V) IODIDES. Brown, D.; Easey, J. F.; Jones, P. J. (Atomic Energy Research Establishment, Harwell, Eng.). J. Chem. Soc., A, No. 10, 1698-1702(1967).

Protactinium pentaiodide, PaI_5, is best prepared by direct union of the elements at 400 to 450° in a vacuum, but, if protactinium is not available, the pentaiodide is obtained in good yield by the reaction of silicon tetraiodide with protactinium pentachloride, pentabromide (both at 150 to 200°), or pentoxide (600°). Protactinium oxyiodides, $PaOI_3$ and PaO_2I, were obtained by reaction of the pentaiodide with antimony trioxide at 150° in vacuo or, less satisfactorily, by the action of oxygen on the pentaiodide. The oxytri-iodide disproportionates above 450° in a vacuum to yield the volatile pentaiodide and a residue of the dioxymonoiodide. The mixed bromo-iodide $PaBr_3I_2$ is obtained when the component pentahalides react together at 350°. Some chemical properties, x-ray powder diffraction results, and infrared spectra are reported for these compounds and for the hexaiodoprotactinate(V), $Ph_3MeAsPaI_6$, which is formed by reaction of the component halides in non-aqueous solvents. Further infrared studies are also reported for the protactinium(V) oxybromides. (auth) (UK)

2056 PRESSURE-JUMP STUDY OF THE KINETICS OF URANYL ION HYDROLYSIS AND DIMERIZATION. Hurwitz,

P. A. (Univ. of Massachusetts, Boston); Atkinson, G. J. Phys. Chem., 71: 4142-4(Nov. 1967).

The pressure-jump method was used for evaluation of rate constants for various equilibrium reactions of the uranyl ion in acidic, aqueous solutions. Results indicated the occurrence of two relaxation effects, which were evaluated in terms of rate constants and equilibrium concentrations. Values of the relaxation times, concentrations of the various uranyl ion species, and rate constants are tabulated. (J.G.B.)

2057 INFRARED STUDY OF POLY-L-PROLINE IN AQUEOUS SOLUTION. Swenson, Charles A.; Formanek, Robert (Univ. of Iowa, Iowa City). J. Phys. Chem., 71: 4073-7(Nov. 1967).

Infrared spectra were measured for aqueous solutions (H_2O and D_2O) of form II poly-L-proline in the fundamental region as a function of temperature. The temperature range includes the region where a reversible phase transition is known to occur. The spectral changes in the carbonyl absorption as this temperature range is approached are interpreted as a breakdown of solute-solvent interactions which result in destabilization of the solute in the solution phase. Simultaneously, there occurs a change in the C-H bending absorption which is interpreted as a small conformational change. Both of these absorptions show apparent isosbestic behavior as a function of temperature. A van't Hoff ΔH° of 60 ± 10 kcal/mole (residue) was estimated for the over-all process from the temperature dependence of the carbonyl absorption. (auth)

2058 THE KINETICS OF THE REACTION BETWEEN NEPTUNIUM(III) AND IRON(III) IN AQUEOUS PERCHLORATE SOLUTIONS. Newton, T. W.; Daugherty, N. A. (Los Alamos Scientific Lab., N. Mex.). Contract W-7405-eng-36. J. Phys. Chem., 71: 3768-73(Nov. 1967). (LA-DC-8657).

Rates of the reaction $Np^{3+} + Fe^{3+} = Np^{4+} + Fe^{2+}$ in aqueous perchlorate solutions are given by $d[Np(IV)]/dt = [Np^{3+}][Fe^{3+}](k_0 + k_{-1}[H^+]^{-1})$ for acid concentrations ranging from 0.05 to 2.0 M at constant ionic strength. The effects of temperature were determined from 0.5 to 36.7°; k_{-1} was from about 4 to 30 times larger than k_0 in this range. The temperature coefficient of k_{-1} was used to determine the activation parameters for the predominant net activation process $Np^{3+} + Fe^{3+} + H_2O = [(Np)(OH)(Fe^{5+})]^* + H^+$, $\Delta F^* = 13.66$ kcal/mole ($k_{-1} = 600$ sec^{-1} at 25°), $\Delta H^* = 14.55 \pm 0.1$ kcal/mole, and $\Delta S^* = 3.0 \pm 0.3$ cal/mole deg. The results for this reaction were compared with those for the similar Pu(IV)-Fe(II) and Np(IV)-Cr(II) reactions. (auth)

2059 PREPARATION OF A NEW THORIUM 8-HYDROXYQUINOLINATE. Cardwell, T. J.; Cattrall, R. W.; Kingston, J. V.; Magee, R. J. (La Trobe Univ., Bundoora, Victoria). Inorg. Nucl. Chem. Lett., 3: 491-3(Nov. 1967).

Although the existence of 8-hydroxyquinolinates of thorium(IV) were previously reported, only the solvated compound $ThQ_4 \cdot HQ$, where $Q = C_9H_6NO$, was previously prepared directly from aqueous solution. The isolation of a lime-green compound corresponding to the formula $Th_2Q_7 \cdot OH \cdot 4H_2O$. This compound when heated to constant weight at 75°C gave the green compound $Th_2Q_7 \cdot OH$. Heating above 125°C produced a steady decomposition of the compound and a loss of organic material. (UK)

2060 APPARATUS FOR THE STUDY OF REACTIONS IN STATIONARY DROPLETS BY RADIOACTIVE TRACERS. Foa, E. (Bar Ilan Univ., Israel); Konigsbuch, M.; Lask, S.; Schachter, O.; Stuhl, Z. J. Sci. Instrum., 44: 936-8(Nov. 1967).

The apparatus described was built to study chemical reactions occurring in stationary droplets of solutions of salts. The reactants are labeled with a suitable radioisotope and maintained at high temperatures under gas flow. It is possible to follow reactions occurring in the droplets by measuring the change in activity of the droplets or the effluent gases or both. The apparatus permits study of the influence of temperature, droplet size, solution concentration, gas composition, humidity, and flow rate on reaction kinetics. (auth) (UK)

2061 METAL β-KETOENOLATE COMPLEXES. Fackler, John P. Jr. (Case Inst. of Tech., Cleveland). Progr. Inorg. Chem., 7: 361-425(1966).

The complexes formed by metals with β-ketoenols are reviewed. Topics included are: recent developments (synthesis, structure, spectral properties, isomers, organic reactions); β-ketoenol complexes with nontransitional elements; β-ketoenol complexes with transitional elements; and solvent-solute interactions. 414 references. (D.H.M.)

2062 ION-EXCHANGE AND ISOTOPE EFFECT OF LITHIUM IONS IN FORMAMIDE. Mori, Yoshihiro; Okabayashi, Tadashi; Kakihana, Hidetake (Shinshu Univ., Agata, Japan). Nippon Kagaku Zasshi, 88: 1053-6(Oct. 1967). (In Japanese).

The ion exchange and the isotope effect of Li^+ ions in the solvent that has higher dielectric constant than water were investigated. The ion-exchange reactions were proceeded in the LiCl solution of formamide at 25°C with sulfonated polystyrene-divinylbenzene resin of NH_4-form(Dowex 50 X1, X2, X4, X8, X12, X16, Diaion SK #1, X24, X36, X55). The isotope effects of Li^+ ions on the ion-exchange reaction were observed. The values of the ion-exchange separation factor $S^{Li}_{NH_4}$ and S^{Li}_{Li} were larger on higher cross-linkage resins in equilibrium. The values of the equilibrium ion-exchange separation factor $S^{Li}_{NH_4}$ and S^{Li}_{Li} were larger on higher crosslinkage resins in equilibrium. The values of the equilibrium ion-exchange separation factor in the formamide system were smaller than those in the water system. The ion-exchange rate was controlled by the diffusion of the ions through the resin particle. The rate was much slower in the formamide system than in the water system. It took about 24 hr to reach the equilibrium when Diaion SK #1-X55(100 to 200 mesh) was used. The stepwise separation factors S^{Li}_{Li} gradually decreased in the process of the reaction (1.012 to 1.005). (auth)

2063 MICROWAVE SPECTRA OF METHYL BROMIDE AND METHYL BROMIDE-d_3. CORIOLIS RESONANCE BETWEEN THE ν_2 AND ν_5 STATES. Morino, Yonezo; Hirose, Chiaki (Tokyo Univ.). J. Mol. Spectros., 24: 204-24(Oct. 1967).

Microwave spectra of $CH_3{}^{79}Br$, $CH_3{}^{81}Br$, $CD_3{}^{79}Br$, and $CD_3{}^{81}Br$ in various excited vibrational states have been measured. The vibration-rotation interaction constant α^B_ν and the vibrational change of the eQq coupling constant have been obtained for the ν_2, ν_3, ν_5, ν_6, and $2\nu_3$ vibrational states of CH_3Br and for the ν_2, ν_3, ν_5, ν_6, $2\nu_3$, $\nu_3 + \nu_6$, and $2\nu_6$ states of CD_3Br. It was found that the l-type doublet in the first excited state of the degenerate vibration ν_5 had unequal separations from the central line. The results are discussed in terms of the Coriolis resonance between the ν_2 and ν_5 states. (auth)

2064 DIATOMIC ISOTOPE EFFECTS AND SECOND-ORDER CORRECTIONS IN THE JWKB APPROXIMATION. Eberhardt, W. H. (Georgia Inst. of Tech., Atlanta). J. Mol. Spectros., 24: 154-62(Oct. 1967).

A method is suggested for testing the reliability of the JWKB technique for studying diatomic vibrations and the construction of potential functions. The vibrational isotope shifts were calculated from the first-order, semiclassical quantization condition and compared with those determined experimentally. Deviations which may be attributed to failure of the first-order approximation were then used to calculate the second-order correction to the phase-integral quantization condition and the potential function constructed by RKR techniques. The technique was applied to ICl and IBr where accurate data exist and the results indicate that the first-order approximation is remarkably accurate to high vibrational excitation but may fail in the energy range very close to dissociation. (auth)

2065 FUNDAMENTAL VIBRATIONS OF FURAN AND DEUTERATED DERIVATIVES. Rico, M.; Barrachina, M.; Orza, J. M. (Instituto de Quimica Fisica Rocasolano, Madrid). J. Mol. Spectros., 24: 133-48(Oct. 1967).

Infrared and Raman spectra of furan, furan-2-5-d_2, furan-3-4-d_2, and furan-d_4, and infrared spectra of furan-2d, furan-3d, and furan-2-3-5-d_3 were analyzed. An assignment of fundamental frequencies for all these compounds based on the rotational envelope of the vapor bands and the state of polarization of Raman lines is proposed. The proposed assignment fits conveniently all the isotopic rules. To check this assignment, special use has been made of the complete isotopic rule. Values of some thermodynamic functions have been calculated for furan at several temperatures. (auth)

2066 REACTIONS OF UNSATURATED HYDROCARBONS WITH DEUTERIUM ON TITANIUM DIOXIDE. Lake, I. J. S.; Kemball, C. (Univ. of Edinburgh). Trans. Faraday Soc., 63: 2535-48(Oct. 1967).

The catalytic reactions of ethylene, propylene, isobutene, benzene, toluene, m-xylene, and hydrogen with deuterium were studied on rutile in the temperature range from 250 to 450°C. Some reactions were also carried out using heavy water in place of deuterium. The olefins that can form allyl radicals were exchanged about 100 times more rapidly than ethylene, and only five of the hydrogen atoms in propylene were replaced by the fast process. Rates of conversion of the olefins to alkanes were similar to the rates of exchange of the hydrogen atoms in ethylene, and the main initial product in each case was the alkane-d_2. All the hydrogen atoms in toluene were exchanged at the same rate, but the ring hydrogen atoms of m-xylene reacted slightly more rapidly than those in the side groups. The exchange reactions involving heavy water occurred at similar rates and with similar activation energies to those with deuterium. The molecules fell into three groups: water, hydrogen, and olefins and alkylbenzenes, in terms of the ease with which they were activated by the catalyst for the exchange pro-

cesses. The nature of the intermediates taking part in the reactions is discussed, and the possibility of mechanisms involving carbanions or carbonium ions is considered. The number of hydroxyl groups on the surface of the catalyst was determined by exchange with deuterium. (auth) (UK)

2067 SPECTROSCOPIC INVESTIGATION ON CARBOXYLIC ACID SOLUTIONS IN THE FAR INFRARED. Statz, G.; Lippert, E. (Technische Univ., Berlin). Ber. Bunsenges. Phys. Chem., 71: 673-9(Oct. 1967). (In German).

Frequencies and intensities of the ir-absorption bands are reported for 27 monocarboxylic acids in solution in the frequency region from 33 to 500 cm^{-1}. The acids are partly deuterated or enriched with ^{18}O. Especially examined are the ir-active vibrations $\nu(OH\cdots O)$; $\gamma(OH\cdots O)$ and $\tau(OH\cdots O)$that result from the association of the acid molecules by hydrogen bonds to ring dimers in the far ir. In the symmetrically substituted formic and acetic acids as well as in the disubstituted acetic acids the frequencies of the three vibrations diminish with increasing mass of the substituent in the sequence D, CH_3, F, Cl, C_6H_5, and Br. The $\nu(OH\cdots O)$-band of benzoic acid is strongly broadened by the rotation of the phenyl ring around its long axis. In the monosubstituted acetic acids two $\nu(OH\cdots O)$-vibrations are appearing for the light substituents CH_3 and CH_2=, for the behavior substituents Cl, C_6H_5 and Br only one $\nu(OH\cdots O)$-band was found with a frequency independent of the mass of the substituent. The $\gamma(OH\cdots O)$-vibration was observed as a weak band in the spectra of all monosubstituted acetic acids. (auth)

2068 ACCOMMODATION OF RARE GASES ON PURE TUNGSTEN AND MOLYBDENUM SURFACES AT ROOM TEMPERATURE. Kouptsidis, Johannes; Menzel, Dietrich (Technische Hochschule, Darmstadt, Ger.). Ber. Bunsenges. Phys. Chem., 71: 720-30(Oct. 1967). (In German).

The thermal accommodation coefficients (a.c.) of the rare gases on polycrystalline filaments of tungsten and molybdenum were measured in an ultrahigh vacuum system using the well-known hot-filament method. The cleanliness of the system was controlled with a field emission microscope; influences of contamination could thus be entirely excluded, so that the results can be regarded as representative for the clean metal surfaces. The influence of variation of the temperature difference between surface and gas was examined; in the present cases this influence is small, and an extrapolation to vanishing temperature difference is easy. The measured a.c. values agree well with the best values available. For the same gas the a.c. values on tungsten and molybdenum differ only slightly; this leads to the conclusion that the elastic constants of the metals are of much higher importance for the energy transfer by collision than the masses of the metal atoms. This result is compared with the existing theories of the energy exchange. (auth)

2069 ELECTROOSMOSIS AND ELECTROPHORESIS IN PAPER ELECTROCHROMATOGRAPHY OF URANYL ION IN SEMICARBAZIDE HYDROCHLORIDE SOLUTION. Lai, Tsai-teh; Wu, Che-kuang (Cheng Kung Univ., Tainan, China). J. Chin. Chem. Soc. (Taiwan), Ser. II, 13: 111-17(Sept. 1967).

Paper electrophoresis in semicarbazide hydrochloride solution showed that uranyl ion formed a positively charged complex at pH 2.25. In 0.4M hydrochloric acid, no detectable uranyl–chloro complexes were formed. Electroosmotic flow created a water film extending from the cathode to the anode, and rendered the transference number of uranyl ion to zero at the margin of the water film. An improved method of paper chromatography is presented. (auth)

2070 THE ABSORPTION OF Es^{3+} IN HYDROCHLORIC ACID SOLUTIONS. Cunningham, B. B.; Peterson, J. R.; Baybarz, R. D.; Parsons, T. C. (Univ. of California, Berkeley). Contract W-7405-eng-48. Inorg. Nucl. Chem. Lett., 3: 519-23 (Nov. 1967). (UCRL-17692).

Observations on the absorption spectrum of Es^{3+} in 3 to 6M HCl in the wavelength region from 3200 to 6500 Å are reported. (auth) (UK)

2071 IDENTIFICATION OF NpO_2 (VI) IN MOLTEN LiCl-KCl EUTECTIC. Martinot, L.; Duyckaerts, G. (Lab. of Nuclear Chemistry, Liege). Inorg. Nucl. Chem. Lett., 3: 507-9(Nov. 1967).

The preparation of NpO_2(VI) in molten LiCl–KCl eutectic by oxidizing a mixture of Np(III) and Np(IV) with oxygen or K_2SO_4 at 450°C is reported. In each experiment a mixture of NpO_2(V) and NpO_2(VI) was obtained, but precipitation of neptunium dioxide never occurred. The ratio $[NpO_2(VI)]/[NpO_2(V)]$ was not affected by the time elapsed, but was slightly decreased by increasing temperature up to 580°C. Proof of the presence of NpO_2(VI) was obtained by voltammetry and chronopotentiometry. (auth) (UK)

2072 DEUTERIUM-HYDROGEN EXCHANGE OF COLLAGEN-LIKE SYNTHETIC POLYPEPTIDES. Heidemann, E.; Bernhardt, H. W. (Technische Hochschule, Darmstadt, Ger.). Nature (London), 216: 263-4(Oct. 21, 1967).

It is stated that, hitherto, studies of tripeptides containing three different amino acids, with an imino acid in position 3, have not shown any tertiary structure. A series of tripeptides corresponding to both the collagen structures proposed by Rich and Crick (J. Molec. Biol. 3: 483 (1961)) and the structure proposed by Ramachandran (Nature 190: 1004 (1961)) were synthesised, polymerised, and the products subjected to fractional crystallization, followed by examination of fractions with similar molecular weights. Studies are reported with collagen films employing the deuterium–hydrogen exchange technique. It was found that the extent of exchange in the solid state in the sequence $(gly\text{-}ala\text{-}pro)_n$ and $(pro\text{-}gly\text{-}ala)_n$ was higher than in $(gly\text{-}pro\text{-}ala)_n$, indicating that the structure $(gly\text{-}pro\text{-}ala)_n$ is more stable than the other sequences. The polypeptides containing the sequence (gly-ala-pro), which corresponds to the Ramachandran two-bonded collagen model, are thus less stable than polypeptides having the sequence (gly-pro-ala), which are capable of forming a one-bonded structure as proposed by Rich and Crick. The greater stability may also arise from the additive H-bonds, which stabilize the quaternary structure favorably formed in the Rich and Crick collagen model. (UK)

2073 ANNUAL REVIEW OF PHYSICAL CHEMISTRY. VOLUME 17. Eyring, H.; Christensen, C. J.; Johnston, H. S. (eds.). Ann. Rev. Phys. Chem., 17: 1-587(1966).

Eighteen chapters are included; one chapter was abstracted separately in NSA. The remaining 17 chapters include information on: the first 45 years of physical chemistry in Germany; thermodynamics; quantum chemistry; statistical mechanics study on intermolecular forces; chemical phenomena at high temperature; kinetics of inorganic reactions in solution; gas kinetics; spin excitations in ionic molecular crystals; chemical applications of Moessbauer spectroscopy; atomic processes at solid surfaces; electron spin resonance; physical organic chemistry; solutions of nonelectrolytes; magnetic optical activity; dielectric polarization and relaxation; electronic spectra of organic molecules; and solvation and structural aspects of electrolyte solutions. (P.C.H.)

For an abstract of the individual paper see: 2129.

2074 REACTION OF CHLORINE TRIFLUORIDE WITH URANYL FLUORIDE. Luce, M.; Hartmanshenn, O. (CEA, Saclay, France). J. Inorg. Nucl. Chem., 29: 2823-4(Nov. 1967). (In French).

Equations previously proposed for the reaction were $2ClF_3 + UO_2F_2 \rightarrow ClO_2F + ClF + UF_6$ (main reaction) and secondary reactions $4ClF + UO_2F_2 \rightarrow O_2 + 2Cl_2 + UF_6$, together with $ClO_2F \rightarrow ClF + O_2$, to explain the small amounts of oxygen and chlorine formed. The reactions $4ClO_2F_2 + UO_2F_2 \rightarrow UF_6 + 2Cl_2 + 5O_2$ and $4ClF_3 + 3UO_2F_2 \rightarrow 3O_2 + 2Cl_2 + 3UF_6$ are proposed and experimental work is described. Temperature effects are discussed. (UK)

2075 CURIUM SESQUIOXIDE, Cm_2O_3. Haug, Hermann O. (Argonne National Lab., Ill.). J. Inorg. Nucl. Chem., 29: 2753-8(Nov. 1967).

Curium sesquioxide was prepared by hydrogen reduction of curium dioxide at temperatures between 700 and 1055°C. In addition to the reported cubic and hexagonal forms, monoclinic Cm_2O_3 (B-type) was found at temperatures higher than 800°C. The unit cell dimensions are $a_0 = 14.282 \pm 0.008$ Å, $b_0 = 3.652 \pm 0.003$ Å, $c_0 = 8.900 \pm 0.005$ Å, $\beta = 100.31 \pm 0.05°$. Monoclinic $^{244}Cm_2O_3$ was remarkably stable towards self-irradiation. (auth) (UK)

2076 KINETICS OF HYDROGEN AND DEUTERIUM ATOM ABSTRACTION BY METHYL RADICALS FROM ETHYLENE DIAMINE AND ETHYLENE DIAMINE-N-d_4. Gray, Peter; Herod, A. A. (Univ. of Leeds, Eng.). Trans. Faraday Soc., 63: 2489-97(Oct. 1967).

The rates of hydrogen-abstraction by methyl radicals from the two different sites in ethylene diamine were measured by using the isotopically different species $NH_2CH_2CH_2NH_2$ and $ND_2CH_2CH_2ND_2$. Arrhenius parameters (based on a value of $10^{13.34}$ cm^3 $mole^{-1}$ sec^{-1} for the dimerization of methyl radicals) were determined. At 150°C the methylene groups are 2.5 times as reactive as the amine groups. In work with unlabelled compounds, the observed rate constant was found to be the sum of two or more separate rate constants. The non-linearity of Arrhenius plots caused by simultaneous reactions with different activation energies was also investigated. The departure from linearity most marked when the separate rate constants are equal, at the isokinetic temperature T^*. If $\mathscr{E}$ is the apparent activation energy and ΔE is the difference in activation energies, then at T^*: $\mathscr{E} = (E_1 + E_2)/2$, and $(d\mathscr{E}/dT) = R(\Delta E/2RT^*)^2$. (auth) (UK)

2077 STUDIES ON PROTACTINIUM OXALATE. Muxart, Roland; Vernois, Jacques; Guillaumont, Robert; Arapaki-Strapelias (Laboratoire d'Arcueil, France). Bull. Soc. Chim. Fr., 8: 2890-2(Aug. 1967). (In French).

Some properties of protactinium oxalate were examined. Ultraviolet reflectance and ir absorption spectra are presented and discussed. The x-ray powder diffraction pattern is rather complex and is not interpreted. (auth)

2078 POLAROGRAPHIC PROPERTIES OF LANTHANIDES. Sevryukov, N. N.; Khasan, M. Z. (Moscow Univ. of United Nations). Zh. Anal. Khim., 22: 1487-95(Oct, 1967). (In Russian).

A study has been made of the effects of pH on the potentials and currents of usual and oscillographic ($I - \varphi$ and $dI/d\varphi - \varphi$) polarograms for La, Nd, Sm, Er, Dy, Lu, Yb, Y, Sc, Al, Th, and Zr on a dropping mercury cathode. Besides the reduction of free H^+, the cathodic process for lanthanum, lanthanides, and yttrium was of two stages, for all the other ions it was of one stage. For all the ions studied, with the exception of Eu^{3+}, Sm^{3+}, and Yb^{3+}, the first stage of the cathodic process can be expressed by the following equation: $[Me(H_2O)_a]^{p+} + 2me + mH^+ \rightarrow [Me(H_2O)_{n-m}(OH)_m]^{(p-m)+} + mH_2$. The second stage of the cathodic process for lanthanum, lanthanides, and yttrium was similar to the first stage, but it was speeded up by autocatalysis due to the formation and decomposition of hydrides. The first stage of the cathodic process for Eu^{3+}, Sm^{3+}, Yb^{3+} was probably characterized by the initial formation of two-charged ions which were then oxidized by water or H^+ with the separation of H_2. (auth)

2079 BORON HYDRIDES. XII. THE SYNTHESIS AND INFRARED SPECTRA OF $NaBH_3D$ AND $NaBD_3H$. (Davis, Robert Earl; Kenson, Robert E. (Purdue Univ., Lafayette, Ind.). Proc. Indiana Acad. Sci., 76: 236-9(1967).

The synthesis of sodium borohydride-d and sodium borohydride-d_3 are reported. The synthesis of the isotopic borohydride ion was based on the reaction: $NaH + R_3NBH_3 \rightarrow NaBH_4 + R_3N$ that was modified by the use of NaD or R_3NBD_3 in the reaction. The infrared spectra of the products formed in the reaction corresponded well with the expected spectra of the isotopic borohydrides. (D.H.M.)

2080 LATTICE CONSTANTS OF $K_7Cm_6F_{31}$; TRENDS IN THE 1:1 AND 7:6 ALKALI METAL–ACTINIDE(IV) SERIES. Keenan, Thomas K. (Los Alamos Scientific Lab., N. Mex.). Inorg. Nucl. Chem. Lett., 30: 391-6(1967). (LA-DC-8896).

The compound $K_7Cm_6F_{31}$ was prepared and its lattice constants were determined. This salt is hexagonal (rhombohedral), Space Group $R\bar{3}$, three molecules per unit cell. Analogous compounds are known for other alkali metal-actinide(IV) fluorides and trends within these series were examined. Values for the lattice constants in the series $K_7Th_6F_{31}$ to $K_7Cm_6F_{31}$ are tabulated, together with values for the series $Rb_7Th_6F_{31}$ to $Rb_7Pu_6F_{31}$. Trends of molecular volume as a function of atomic number are indicated graphically. (auth) (UK)

2081 THORIUM–AMMONIUM AURIN TRICARBOXYLATE CHELATE. Sangal, Satendra P. (Univ. of Allahabad, India). Vignana Prishad Anusandhan Patrika, 9: 81-5(Apr. 1966. (In Pakistanian).

Formation of a pink colored chelate between thorium and ammonium aurin tricarboxylate (λ max 540 mμ) was reported at pH 5.0. The composition of the chelate as determined by the mole ratio method and the slope method is 1:1 (metal:chelating agent). The value of log K was determined by the mole ratio method and is 5.0 at 25°C. The chelate was stable between pH 4.0 and 7.5. (auth)

2082 A LEED STUDY OF CO AND CO_2 ADSORPTION ON Mo(110). Jackson, A. G.; Hooker, M. P. Surface Sci., 6: 297-308(Mar. 1967).

The adsorption of CO and CO_2 onto a Mo(110) surface has been studied by LEED techniques. CO_2 is adsorbed in an amorphous layer. No pattern associated with a CO_2 structure could be found in the temperature range 20 to 1000°C. CO forms a complex structure on Mo(110) at 1000°C, indicating an activation energy requirement for structure formation. Changes in intensity resulting from the CO adsorption are given. A peak voltage shift resulting from CO adsorption is noted and briefly discussed. (Rev. Met. Lit.)

2083 REACTIONS OF TcO_4^- AND ReO_4^- WITH HYDROGEN SULFIDE, PREPARATION OF TETRATHIOPERRHENATE IONS IN SOLUTION. Mueller, A.; Krebs, B.; Diemann, E. Z. Anorg. Allg. Chem., 353: 259-64(Sept. 1967). (In German).

The reaction of TcO_4^- and ReO_4^- ions with hydrogen sulfide in an aqueous solution was investigated by measuring the electronic absorption spectra. Using a simple molecular orbital diagram the existence of the ReS_4^- ion in solution was proved. The electron absorption spectrum of the tetrathioperrhenate ion was assigned. Small amounts of TcO_3S^- were possibly formed by the reaction of TcO_4^- with H_2S. (auth)

2084 QUENCHING OF EXCITED SINGLET STATES OF AROMATIC HYDROCARBONS BY CONJUGATED DIENES. Stephenson, L. M.; Whitten, D. G.; Hammond, G. S. (California Inst. of Tech., Pasadena). pp 35-42 of Chemistry of Ionisation and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21–23, 1966. See CONF-660955.

Fluorescence of a number of aromatic hydrocarbons is quenched by conjugated dienes, despite the fact that the conditions of classical transfer of electronic excitation are not met. A mechanism involving formation of excited complexes having very fast rates of non-radiative decay is discussed in somewhat nonspecific terms. (auth) (UK)

2085 ABSOLUTE RATES OF HYDROGEN ATOM REACTIONS IN AQUEOUS SOLUTION. Baxendale, J. H.; Bevan, P. L. T. (Univ. of Manchester, Eng.). pp 253-7 of Chemistry of Ionisation and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21–23, 1966. See CONF-660955.

The absolute rate constant for the reaction $Ag^+ + H \rightarrow Ag^0 + H^+$ was measured using the electron pulse technique. The value $k = 1.1 \times 10^{10}$ M^{-1} sec^{-1} confirmed an earlier preliminary value. Rate constants for hydrogen atom reactions with methanol, ethanol, isopropanol, n-propanol, glycol, glycerol, glycine, and dioxan were obtained by competing these reactions with the Ag^+ reaction. The results were compared with earlier values where available. (auth) (UK)

2086 APPLICATION OF THE THEORY OF DIFFUSION-CONTROLLED REACTIONS TO KINETIC SALT EFFECTS OF THE HYDRATED ELECTRON. Logan, S. R. (Univ. of Strathclyde, Glasgow). pp 295-302 of Chemistry of Ionisation and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21–23, 1966. See CONF-660955.

The refinements to the theoretical derivation of kinetic salt effects of fast reactions that become necessary when solute concentrations are high are shown always to cause the slope to become more positive or less negative. The unusual salt effects shown by the $e_{aq}^- + I_3^-$ reaction are, however, not explained in this way. Other reported salt effects, both for "normal" and "special" conditions, are shown to be in accord with the general predictions of this theory. (auth) (UK)

2087 PLUTONIUM HANDBOOK. A Guide to the Technology. Volume I. Wick, O. J. (ed.). New York, Gordon and Breach, Science Publishers, 1967. 520p. $22.25.

The Plutonium Handbook, Vol. 1 is divided into 3 sections: physics, metallurgy, and chemistry. These three sections are comprised of 13 chapters. Separate abstracts were prepared for each chapter. (B.L.M.)

For abstracts of individual chapters see: 2088–2090, 2577, 2627, 2632–2634, 2655, 2656, 2699, 3737, and 3738.

2088 CHEMICAL PROPERTIES. Cleveland, J. M. (Dow Chemical Co., Golden, Colo.). pp 327-33 of Plutonium Handbook. A Guide to the Technology. Vol. I. Wick, O. J. (ed.). New York, Gordon and Breach Science Publishers, 1967.

Because Pu chemistry and its processing applications are best considered in the context of the actinide theory, this theory is discussed. Special aspects of Pu, either in solution or in compounds prepared from solutions, are also considered. The dissolution of Pu is described. (B.L.M.)

2089 COMPOUNDS OF PLUTONIUM. Cleveland, J. M. (Dow Chemical Co., Golden, Colo.). pp 335-401 of Plutonium Handbook. A Guide to the Technology. Vol. I. Wick, O. J. (ed.). New York, Gordon and Breach Science Publishers, 1967.

A review of the literature covering Pu compounds is presented The preparation, solid chemistry, and solution chemistry of some compounds are presented. Not all data are available for all compounds. In many cases thermodynamic and x-ray crystallographic data are tabulated. Data for the stable compounds of Pu(III) and Pu(IV) with some attention to the less stable compounds of Pu(V)

and Pu(VI) are given. Stoichiometry and hydration of the compounds are discussed. Data on the following compounds are included: hydrides, oxides, halides, carbonates, oxalates, sulfates, nitrates, phosphates, carbides, silicides, nitrides, phosphides, arsenides, sulfides, and tellurides. Some other miscellaneous compounds are briefly discussed. (237 references) (B.L.M.)

2090 SOLUTION CHEMISTRY OF PLUTONIUM. Cleveland, J. M. (Dow Chemical Co., Golden, Colo.). pp 403-520 of Plutonium Handbook. A Guide to the Technology. Vol. I. Wick, O. J. (ed.). New York, Gordon and Breach Science Publishers, 1967.

The complex solution chemistry of Pu is due in large part to the multiplicity of oxidation states. The hydrolysis of the various oxidation states is discussed in detail, as are the complexes of the various oxidation states. Both ion-exchange behavior and solvent-extraction behavior of Pu are discussed in detail. Finally, the status of research on the molten chemistry of Pu is reviewed. (316 references). (B.L.M.).

Radiation and Nuclear Chemistry

2091 (BNL-11849) RADIONUCLIDE MILKING SYSTEMS. Richards, P. (Brookhaven National Lab., Upton, N. Y.). Oct. 17, 1967. 18p. (CONF-671112-1). Dep. CFSTI.

From 8th Conference on Radioisotopes and Exhibition of Nuclear Instruments, Materials and Products, Tokyo, Japan.

The development and use of the radionuclide "milking system" or nuclide "generator" is reviewed. Principles of operation of the generator are discussed. Decay schemes involved in 5 nuclide milking systems, ^{132}I, ^{99m}Tc, ^{81m}Sr, ^{68}Ga, and ^{113m}In, are indicated. Potential milking systems are discussed. (M.C.G.)

2092 (CEA-R-3239) PREPARATION DE ^{198}Au EXEMPT DE ^{199}Au. (Preparation of ^{198}Au Free From ^{199}Au). Capgras, Andree (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). May 1967. 9p. (In French). Dep.

It was found that by irradiating ^{197}Au under a Cd cover in a neutron flux with a fast flux/thermal flux ratio of the order of 0.1, ^{198}Au containing less than 0.1% ^{199}Au could be obtained. (D.C.W.)

2093 (CEA-R-3250) ETUDE PAR LA TECHNIQUE DE RESONANCE PARAMAGNETIQUE ELECTRONIQUE DES RADICAUX CREES SOUS IRRADIATION DANS LA GLYCINE. (Study by Electron Spin Resonance of the Free Radicals Created Under Irradiation in Glycine). Thomet, Paul; Rassat, Andre; Servoz-Gavin, Pierre; de Choudens, Henri (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). Aug. 1967. 34p. (In French). Dep.

Free radicals created by different radiations in glycine were measured by electron spin resonance and their number evaluated as a function of the absorbed dose. This number decreased when the LET of the radiations increased; high LET radiations gave less radiochemical effects, whereas high LET radiations create more damage in biological materials. The decreasing with time of the number of free radicals and the speed of this decrease was a function of temperature; by study of the kinetics of this decrease, an attempt was made to prove the presence of three radicals. (auth)

2094 (COO-1224-14) ENERGY TRANSFER IN POLYMETHYL METHACRYLATE. Ward, Donald Richard (Illinois Inst. of Tech., Chicago). June 1967. Contract AT(11-1)-1224. 171p. Dep. CFSTI.

Thesis.

Energy transfer in polymethyl methacrylate (PMMA), containing small amounts of p-terphenyl and nonluminescent aromatic molecules or sinks, was studied by measuring the fluorescence of the irradiated samples. The samples were excited with ultraviolet radiation to produce excited electronic states and then with beta particles to generate excited electronic states and positive ions. Intermolecular energy transport was found to be more prevalent than intramolecular. Intermolecular energy transfer involves a three dimensional random walk which is suitable for analysis by a Markov chain random walk treatment. The applicability of the Markov Chain treatment to the data supports the theory that in PMMA systems the energy is localized, that the migration of excited states is a random walk process and that transfers between and from PMMA chain units do not proceed mainly via Förster's mechanism. In addition it supports the role of positive ions in energy transfer. (128 references) (auth)

2095 (COO-1224-15) ENERGY TRANSFER AND RADIATION PROTECTION IN THE RADIOLYSIS OF POLY(METHYL-METHACRYLATE) STEREOISOMERS AND COPOLYMERS. Henry, George A. (Illinois Inst. of Tech., Chicago). June 1967. Contract AT(11-1)-1224. 119p. Dep. CFSTI.

Thesis.

Electron and ultraviolet irradiation of poly(methyl methacrylate) containing different additives and of syndiotactic and isotactic polymethyl methacrylate were carried out. Studies were made to see whether protection of the poly(methyl methacrylate) by energy transfer to the additives (e.g., cumene and α-methylstyrene) occurred, and whether either intermolecular or intramolecular energy transfer was the dominant mode in these systems. The effects of irradiation on mixtures of isotactic and syndiotactic poly(methyl methacrylate) were also investigated. A mathematical treatment involving the use of Markov chain theory was used to explain the results. The electron irradiations were carried out with 13 MeV electrons from a linear accelerator. Thin films of polymer samples were irradiated with 2537 Å ultraviolet light. The degradation of the polymers was followed by the change in molecular weight as measured by viscometry of dilute solutions in benzene. Results indicated that isotactic poly(methyl methacrylate) is more stable to electron and uv irradiation than syndiotactic poly(methyl methacrylate). Mixtures of these stereoisomers formed by dissolving the polymers in methylene chloride when irradiated (as thin films), with ultraviolet light, displayed enhanced stability in the region of 30 to 50 wt % isotactic isomer. This is probably due to the formation of a stable complex between the stereoisomers. For the case of electron irradiation of polymethyl methacrylate containing cumene and α-methylstyrene the mathematical treatment showed that energy transfer to the sinks is from 20 to 40 times more probable then internal conversion. For ultraviolet irradiation, energy transfer to the sinks was five times as probable. In addition energy migration was primarily intramolecular The Markov chain treatment also showed that the energy transfers by a series of random jumps. (auth)

2096 (CU-2791-6) EFFECTS OF RADIATION ON THE CHEMICAL ACTIVITY OF CERTAIN SOLID OXIDE CATALYSTS. Final Report. (Columbia Univ., New York. Radiation Chemistry Research Group). Mar. 1966. Contract AT(30-1)-2791. 13p. Dep. CFSTI.

The behavior of chromia, alumina, and zinc oxide catalysts was observed with a flow system before, during, and after irradiation in the field of a nuclear reactor. Hydrogen–deuterium exchange was used as the tool for indicating changes in catalytic activity. Results showed that alumina is strongly affected by radiation, but the induced activity is short-lived. Poisoning of zinc oxide by radiation was observed, but this effect was apparently caused by an impurity in the gas. Developments are also reported for studies on the effects of gamma radiation on chemisorption of oxygen on anatase titania and the kinetics of ethylene hydrogenation on various solid oxide catalysts. (auth)

2097 (EUR-3560f) PRODUCTION D'ELEMENTS LOURDS PAR IRRADIATION D'AMERICIUM 241 DANS LE REACTEUR BR 2. (Production of Heavy Elements by Irradiation of ^{241}Am in the BR 2 Reactor). Hebel, W. (Centre d'Etude de l'Energie Nucleaire, Mol (Belgium)). Sept. 1967. Contract 006-60-5 BRAB. 26p. (In French). Dep.

A review is presented on some of the problems encountered in the production of heavy elements by irradiation with americium-241. An examination was made of the application of criteria to an irradiation program to be carried out in the BR 2 high-flux test reactor (Mol, Belgium) for Euratom's European Institute of Transuranium Elements. The problems raised by an americium irradiation program, especially the activity of non-irradiated targets, the production of heat, and the formation of gaseous products are considered, along with the production of heavy elements in nuclear reactors with thermal neutron fluxes of several times 10^{14} n/cm^2/sec. (auth)

2098 (IFA-ESR-16) E. S. R. STUDY OF SOME Cr(VI) IRRADIATED COMPOUNDS. Constantinescu, O.; Pascaru, I.; Constantinescu, M. (Academia R. P. R., Bucharest. Institutul de Fizica Atomica). June 1967. 12p. Dep.

The behavior on radiolysis of $CrO_4(NH_4)_2$ and CrO_3K_2 were studied by ESR. In the case of polycrystalline $CrO_4(NH_4)_2$ irradiated with γ rays and with neutrons, the formation of Cr(V) and Cr(III) was observed. The ESR spectra of CrO_4K_2 irradiated under the same conditions, suggested the formation of radicals of CrO_3^- type. A mechanism of the production by radiolysis of the paramagnetic species formed was proposed. (auth)

2099 (TID-24136) RADIATION CHEMISTRY AND PHOTOCHEMISTRY PROGRAM. Progress Report No. 1, January–September 1967. Daniels, Malcolm (Oregon State Univ., Corvallis. Dept. of Chemistry). Contract AT(45-1)-2014. 8p. (RL-2014-1). Dep. CFSTI.

Research is being carried out on the radiation chemistry and photochemistry of aqueous solutions and water. Excited states and transient species in the radiolysis and photolysis of DNA are being studied. (M.C.G.)

2100 (UJV–1883) THE OPTICAL APPROXIMATION, PRIMARY RADIATION CHEMICAL YIELDS, AND STRUCTURE OF THE TRACK OF AN IONIZING PARTICLE. Santar, I.; Bednar, J. (Ceskoslovenska Akademie Ved, Rez. Ustav Jaderneho Vyzkumu). Aug. 1967. 21p. Dep.

Recent efforts in the theory of primary radiation chemical yields are summarized. Particular emphasis is put on the close connection between the approach used in this theory and the description of initial structure of the track of an ionizing particle. (auth)

2101 INVESTIGATION BY THE EPR METHOD OF THE INTERMEDIATE PRODUCTS OF α RADIOLYSIS OF AQUEOUS SOLUTIONS OF NITRIC ACID. Vashman, A. A.; Savel'ev, Yu. I.; Vladimirova, M. V. Radiokhimiya, 9: 351-5(1967). (In Russian).

The OH, NO_2, and NO_3 radicals formed during α radiolysis of aqueous solutions of nitric acid were detected and identified by the EPR method. The radiation yields of the free radicals varying from 0.22 in 0.01 M HNO_3 up to 1.22 radicals/100eV in 4.0 M HNO_3 were determined. The redical mechanism for the formation of OH in concentrated solutions of nitric acid was confirmed. It was found that the NO_3 radical displays a triaxial paramagnetic center, the hyperfine structure of which was probable caused by the dipole-dipole interaction. (tr-auth)

2102 SZILARD–CHALMERS REACTION IN THE DIVALENT COBALT PHTHALOCYANINE. Kirin, I. S.; Ivanchenko, A. F.; Moskalev, P. N. Radiokhimiya, 9: 346-51(1967). (In Russian).

Divalent Co phthalocyanine was synthesized from Co complexes with dimethylamine and o-phthalodinitrile. The use of neutron-irradiated Co phthalocyanine for concentration of the ^{60}Co isotope with sulfuric acid as a solvent made it possible to determine the enrichment coefficient as $\sim 2 \times 10^2$ with yields of radioactive Co of ~95%. During eight hours at room temperature in aniline solution the isotopic exchange of Co introduced in the phthalocyanine compound and occurring in the solution, was not observed. An hypothesis was made on the joining in the aniline solution to Co phthalocyanine molecules together with aniline and also Co aniline complexes with formation of stable compounds. Tests on the separation of phthalocyanine and aniline complexes of Co were carried out. (tr-auth)

2103 EFFECT OF THE SIZE OF THE LINEAR ENERGY TRANSFER OF RADIATION ON THE PRODUCT YIELD IN THE RADIOLYSIS OF WATER. Vladimirova, M. V. Radiokhimiya, 9: 386-8(1967). (In Russian).

In previous studies on the yield of H_2 and Fe^{3+} in 0.8 N sulfuric acid for different forms of radiation, a dependence between $G(H_2)$, $G(Fe^{3+})$, and the magnitude of the linear energy transfer was detected. Equations expressing this dependence were derived. (J.S.R.)

2104 PREPARATION OF ^{54}Mn AND ^{67}Cu IN A REACTOR. Sirtesh, L.; Zhinka, L. Radiokhimiya, 9: 389-92(1967). (In Russian).

The preparation of carrier-free ^{54}Mn and ^{67}Cu by the (n,p) reaction was investigated. The targets used were the oxides of iron and zinc. The radioactive isotopes, after reactor irradiation of the targets, were separated by ion-exchange resins. The results showed that ^{54}Mn and ^{67}Cu could be produced with relatively high yield under reactor conditions. (J.S.R.)

2105 POLYETHYLENES FORMED BY THE γ-RADIATION-INDUCED POLYMERIZATION IN VARIOUS ALCOHOLS. Mitsui, Hiroshi; Suganuma, Fujio; Machi, Sueo; Hagiwara, Miyuki; Kagiya, Tsutomu (Japan Atomic Energy Research Inst., Takasaki). J. Polym. Sci., Part B, 5: 997-1000(Nov. 1967).

The yields and molecular weights of gamma-radioinduced ethylene polymers formed in alcohols, except tert-butyl alcohol, were lower than those of bulk polymerization under the same conditions. The yield was increased and the molecular weight reduced to about one half by the addition of tert-butyl alcohol. Infrared spectra of the polymers obtained by ethylene polymerization in various alcohols displayed several absorption bands assigned to the alcohols besides typical polyethylene bands. Results indicated that the hydroxyl groups in the polymers obtained by γ-radioinduced polymerization of ethylene in methyl, n-propyl, isopropyl, and tert-butyl alcohols are primary, primary and secondary, secondary and tertiary, and tertiary, respectively. (J.G.B.)

2106 EFFECT OF RADIATION ON THE SELECTIVITY OF YTTRIUM OXIDE IN THE DECOMPOSITION OF ISOPROPYL ALCOHOL. Spitsyn, Vikt. I.; Pirogova, G. N.; Korosteleva, R. I.; Glazunov, M. P. Dokl. Akad. Nauk SSSR, 173: 388-91 (Mar. 11, 1967). (In Russian).

The decomposition of isopropyl alcohol on radioactive yttrium oxide was studied in order to confirm the effects of neutron irradiation on the dehydrogenation and dehydration reactions. Effects of various irradiation energies were studied with ^{90}Y($T_{\frac{1}{2}}$ = 64.6 hr, E_β = 2.18 MeV) and ^{91}Y($T_{\frac{1}{2}}$ = 57.5 days, $E_{\beta max}$ = 1.55 MeV and $E_{\gamma max}$ = 1.2 MeV). Radioactive isotopes were introduced into the catalyst by irradiation in a nuclear reactor and by saturation with a radioactive salt solution. In a reactor it was treated by 1.2×10^{13} n/cm^2 sec slow neutron flux with 30-min to 4-hr exposure. Analysis of the spectra of the irradiated preparations indicated the presence of 0.01% of ^{160}Tb ($T_{\frac{1}{2}}$ = 73 days, $E_{\beta max}$ = 0.86 MeV, $E_{\gamma max}$ = 0.962 MeV) in addition to ^{90}Y. The curves of selectivity of yttrium oxide irradiated in a nuclear reactor and selectivity of the Y_2O_3 + 1.9% $Y^*(NO_3)_3$ catalyst and yttrium oxide containing $^{91}Y(NO_3)_3$ are included. The results showed that neutron irradiation of the catalyst accelerated dehydrogenation and slowed down dehydration reactions. (R.V.J.)

2107 RADIOCHEMICAL GRAFTING TAKING PLACE BY AN IONIC MECHANISM. Chapiro, Adolphe; Jendrychowska-Bonamour, Anna-Maria (CNRS, Bellevue, France). Compt. Rend., Ser. C, 265: 484-7(Aug. 21, 1967). (In French).

Isobutylene was grafted on poly(vinyl chloride) (PVC) by irradiating films of PVC inflated from the monomer in the presence of chloroform at −78 and −196°C. It is the first known example of a radiochemical grafting proceeding by the cationic route. The reaction attains a ratio of grafting limited to 20 to 22 percent. The results suggested that radiolysis of PVC leads to polymeric cations on which growing branches of isobutylene have been fixed. (tr-auth)

2108 THE REACTIONS OF CARBON ATOMS AND METHYNE (CH) WITH HYDROGEN AND ETHYLENE. Mackay, Colin; Nicholas, John; Wolfgang, Richard (Yale University, New Haven, Haverford College, Pa.). J. Amer. Chem. Soc., 89: 5758-66(Nov. 8, 1966).

^{11}C produced by nuclear recoil was used to examine the reactions of free carbon atoms with hydrogen. Reaction with added ethylene was used to intercept CH, CH_2, and CH_3 intermediates. Product yields were measured as a function of the relative pressures of hydrogen and ethylene at constant total pressure, as a function of total pressure, and in the presence of oxygen and iodine scavengers. Methyne (CH) was found to react with ethylene to give an allyl radical, which reacted further to yield pentene-1. This product served as an indicator of the amount of CH formed. CH_2 was estimated through the yields of its reaction products with ethylene, propylene, and cyclopropane. The results obtained serve to outline the complex series of processes in the $C-H_2-C_2H_4$ system. It is possible to identify an initial reaction involving addition of hot C atoms to H_2 to form excited CH_2 that can either be stabilized by collisional deactivation or can dissociate to CH. This process is considerably less efficient than addition of C to ethylene, possibly because nonlinear CH_2 complexes revert promptly to C + H_2. A kinetic analysis allows estimation of the average energy of the reacting hot C atom and also provides a basis for quantitative and semiquantitative estimates of the relative rate constants involved. Both CH_2 and CH show somewhat higher reactivity toward C_2H_4 than toward H_2, but the difference in reactivity is greater for CH. This is consistent with the fact that in these studies, CH_2 must be formed with higher average translational energy than is CH. (auth)

2109 HOT-ATOM SYNTHESIS OF PHENYLMERCURIC COMPOUNDS. Wheeler, O. H.; McClin, M. L. (Puerto Rico Nuclear Center, Mayaguez). Int. J. Appl. Radiat. Isotop., 18: 788-9(Nov. 1967).

In previous studies it was found that phenylmercuric chloride is unstable to radiation and could not be prepared in high specific activity by direct neutron activation. The studies were also complicated by the instability of diphenylmercury to gamma radiation and by the exchange of diphenylmercury with mercuric compounds. A reinvestigation of the neutron activation of diphenylmercury, and also that of phenylmercuric acetate and chloride, was made in order to determine whether, in fact, these compounds could be labeled with ^{203}Hg by direct activation. The reactor neutron flux employed was 10^{12}n/cm^2/sec, with a gamma ray flux of $\sim 2 \times 10^6$ R/hr. Activation of solid diphenylmercury for 10 min resulted in >99% of the activity, which was soluble in benzene being "retained" in the original compound, with only a trace of phenylmercuric compounds. A similar distribution was found on activation in benzene solution. Reaction mechanisms are discussed. Activation for 2 hr resulted initially in 97% labeled phenylmercuric compounds, although after standing for 3 days 88% labeled diphenylmercury was found, presumably resulting from disproportionation of the active phenylmercuric compounds. Exchange with mercury was unlikely to occur under the experimental conditions employed. Phenylmercuric acetate, on activation for 2 hr, retained most of the activity (84%), with some diphenylmercury (5%) and inorganic mercury (3%). Phe-

nylmercuric chloride gave 70% phenylmercuric compounds and 24% diphenylmercury, and the distribution was little affected by reducing the activation time to 10 min. (UK)

2110 ELECTRON SPIN RESONANCE STUDY OF DISSOCIATIVE ELECTRON CAPTURE PROCESSES IN GAMMA IRRADIATED AMINO-ACIDS. Ayscough, P. B.; Mach, K.; Oversby, J. P.; Roy, A. K. (Univ. of Leeds, Eng.). Chem. Commun., 21: 1084-5(1967).

Dissociative electron capture processes are considered to be important in the low-temperature radiolysis of alkyl halides, nitriles, halogeno-carboxylic acids, etc. For example RX + $e^- \rightarrow (RX^-) \rightarrow R\cdot + X^-$, where the reaction is favoured by the high electron affinity of X. It was suggested that a similar reaction occurs in the radiolysis of amino-acids, thus $RCH(NH_3^+)CO_2^- + e^- \rightarrow RCH(NH_3^+)CO_2^{2-} \rightarrow R\dot{C}H\cdot CO_2^- + NH_3$, since NH_3 is a major product and radicals of the structure $R\dot{C}HCO_2^-$ are commonly observed following gamma irradiation at room temperature. Reports of transient ESR spectra observed at 77°K in γ-irradiated carboxylic and amino acids, attributed to radical-ions such as $CH_3(CO_2H)_2^-$ and $NH_3^+CH_2\cdot CO_2^{2-}$, support this view. The ESR spectra of a group of amino acids $RCH(NH_3^+)CO_2^-$, where R = H, Me, Et, $CH_2\cdot CO_2H$, and $CH_2\cdot SO_3H$, were examined after γ-irradiation at 77°K. Evidence was found for transient radical-anions with g = 2.0035 ± 0.005 in all the pure compounds, but only for cysteic acid in the aqueous glasses examined. Salient features of the spectra are tabulated, and attempts made at interpretation. It was concluded that in all cases the species trapped initially at 77°K are formed by electron capture and have the unpaired spin localised in the carbonyl group; are probably stabilised by protonation, and decay by loss of NH_3 to give $R\dot{C}H\cdot CO_2H$, which may subsequently abstract H from the parent molecule. This conclusion is supported by studies of γ-irradiated aqueous alkaline glasses containing amino acid, in which systems protonation is unlikely. The total evidence appears to rule out the possibility that the initially trapped species are the parent molecular cations. (UK)

2111 NEW ELECTRON SPIN RESONANCE SPECTRA IN γ-IRRADIATED ALKYL HALIDES AT 77°K. Egland, Richard J.; Willard, John E. (Univ. of Wisconsin, Madison). Contract AT(11-1)-1715. J. Phys. Chem., 71: 4158-9(Nov. 1967). (COO-1715-131).

ESR sensitivities ranging up to several hundred times that required to give full-scale deflection for alkyl radicals produced by radiolysis of glassy alkyl halides were used. All γ-irradiated, glassy, polycrystalline alkyl iodides and bromides tested gave ESR spectra at much lower and higher magnitudes than previously observed. It was concluded that the low- and high-field spectra are caused by halogen-containing species. (J.G.B.)

2112 EVIDENCE OF THE O_3^- RADICAL IN IRRADIATED SODIUM BROMATE BY ELECTRON SPIN RESONANCE. Andersen, T.; Byberg, J. R.; Olsen, K. J. (Univ. of Aarhus, Denmark). J. Phys. Chem., 71: 4129-31(Nov. 1967).

Single crystals of $NaBrO_3$ were irradiated with 10-MeV electrons at −78° and at room temperature. ESR spectra of a number of different paramagnetic centers were observed immediately after the irradiation. Storing at 80 to 100° for several days destroyed the majority of the paramagnetic centers. However, one center, A, survived this treatment. It decayed in a few hours at 130°. ESR spectral studies and a comparison of g values of A with those for O_3^- provide evidence for the existence of O_3^- in $NaBrO_3$. (J.G.B.)

2113 REACTION RATES OF ALKYL AND PEROXY RADICALS WITH COPPER ION: PULSE RADIOLYSIS STUDIES. MacLachlan, A. (E. I. Du Pont de Nemours and Co., Wilmington, Del.). J. Phys. Chem., 71: 4132-3(Nov. 1967).

The pulse radiolysis technique was applied to the direct observation of the rates of interaction of substituted alkyl and peroxy radicals with Cu^+ and Cu^{2+} ions. Radicals were generated from three solvent systems: ethanol, 98% ethanol−2% acetic acid, and glacial acetic acid. The efficiencies and rates of interaction of Cu ions with the radicals produced were examined. Some effects of radical structure and ligands were also studied. (J.G.B.)

2114 RADIOLYTIC PRODUCTS OF LIQUID AMMONIA. Sutherland, J. W.; Kramer, H. (Brookhaven National Lab., Upton, N. Y.). Contract AT(30-2)-Gen-16. J. Phys. Chem., 71: 4161-2(Nov. 1967). (BNL-10990).

Studies on the gamma radiolysis of liquid ammonia indicated the formation of at least two products other than H_2, N_2, and N_2H_4. Spectral studies revealed the presence of HN_3 at doses $>40 \times 10^3$ RAD and other hydronitrogen species, possibly N_3H_2, N_3H_3, or N_4H_4, at doses $<30 \times 10^3$ RAD. (J.G.B.)

2115 THE REACTIONS OF HYDROGEN ATOMS WITH BENZENE AND TOLUENE STUDIED BY PULSED RADIOLYSIS: REACTION RATE CONSTANTS AND TRANSIENT SPECTRA IN THE GAS PHASE AND AQUEOUS SOLUTION. Sauer, Myran C. Jr.; Ward, Barry (Argonne National Lab., Ill.). J. Phys. Chem., 71: 3971-83(Nov. 1967).

The rate constants at 25° for the gas-phase reactions of hydrogen atoms with benzene and toluene were determined by the technique of pulsed radiolysis and are, in units of $\underline{M}^{-1}$ sec^{-1}, 0.37×10^9 and 1.0×10^9, respectively. The activation energy in the case of benzene was about 3 kcal/mole. In aqueous solution, the corresponding rate constants were determined to be 1.1×10^9 and 2.6×10^9, respectively. The limits of error on these rate constants were ca ±20%. The rate constants were measured by following, as a function of time, the formation of the optical absorption due to radicals produced when hydrogen atoms, produced by an electron pulse, reacted with the aromatic compound. Benzene and toluene yielded the cyclohexadienyl radical and the methylcyclohexadienyl radical, respectively, with absorption maxima at 302 and 307 mμ, respectively, in the gas phase. The half-widths of the absorption peaks were about 30 mμ. In aqueous solution, the absorption maxima were 311, (ϵ^{311} (5.4 ± 0.5) × 10^3 $\underline{M}^{-1}$ cm^{-1}) and 315 mμ, respectively, with half-widths similar to those in the gas phase. The combination of two cyclohexadienyl radicals proceeded at least as fast as once every ten collisions in the gas phase at 25°, indicating a "loose" activated complex. In the liquid phase, the combination was diffusion controlled. (auth)

2116 PRODUCTION OF ISOMERIC NITROPHENOLS IN RADIOLYSIS OF AQUEOUS NITROBENZENE SOLUTION. Matthews, R. W.; Sangster, D. F. (Australian Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales). J. Phys. Chem., 71: 4056-62(Nov. 1967).

The isomeric distribution of nitrophenols formed during the radiolysis of aerated aqueous nitrobenzene was studied. The o-nitrophenol yield was affected by addition of 0.1 m$\underline{M}$ dichromate and varied with dose rate, whereas the m- and p-nitrophenol yields were substantially unaffected. The results show that all three isomers may be formed by unimolecular or pseudo-unimolecular decomposition of the corresponding oxygenated nitrobenzene-hydroxyl radical adduct. In the case of the ortho product there is, however, a competing reaction whereby pairs of ortho adducts undergo bimolecular dismutation giving half the number of nitrophenol molecules. The yield may be further reduced by a recombination reaction between the ·OH adduct and the nitrobenzene-reducing radical adduct. Dichromate reacts rapidly with the nitrobenzene–hydroxyl radical adduct preventing the two bimolecular reactions and giving nitrophenol in equivalent yield. The isomeric product ratios ortho : meta : para are 2 : 1 : 1. These ratios reflect the extent of attack of hydroxyl radical at different positions of the aromatic ring and are those expected of a very reactive homolytic reagent with some electrophilic character. (auth)

2117 ELECTRON CAPTURE BY NITROUS OXIDE IN IRRADIATED ALKANE AND ALKENE GASES. SUBSEQUENT REACTIONS OF THE O^- ION. Warman, John M. (Mellon Inst., Pittsburgh). Contract AT(30-1)-2310. J. Phys. Chem., 71: 4866-72(Nov. 1967). (RRL-2310-200).

The yields of nitrogen formed on irradiation of alkane (C_2, C_3, C_4) and alkene (C_3, C_4) gases containing small amounts (<5%) of added nitrous oxide were measured. The yield of nitrogen, $G(N_2)$, for a given hydrocarbon increased with increasing concentration of nitrous oxide up to ~2% above which $G(N_2)$ was approximately constant. This limiting yield, $G(N_2)_\infty$, depends upon the hydrocarbon used, being for the alkanes 1.55G_e (G_e = yield of electrons/100 eV), for propylene and isobutylene ~G_e, and for the 1- and 2-butenes ~2G_e. These differences in the value of $G(N_2)_\infty$ were attributed to subsequent reactions of the O^- ion, formed on electron capture by the nitrous oxide, in the case of the alkane + N_2O systems with nitrous oxide and in the case of the alkene + N_2O systems with the alkene. Rate constant ratios for these reactions were determined by studying mixed-hydrocarbon + N_2O systems and by the use of carbon dioxide and acetone as competitive scavengers of the O^- ion. (auth)

2118 DETECTION OF TRAPPED ELECTRONS IN ORGANIC GLASSES AFTER GAMMA IRRADIATION AT 4.2°K BY ELECTRON SPIN RESONANCE SPECTROSCOPY. Smith, D. R.; Pieroni, J. J. (Atomic Energy of Canada Ltd., Chalk River, Ont.). Can. J. Chem., 45: 2723-7(Nov. 15, 1967). (AECL-2956).

Several organic glasses, which are known to form trapped electrons when gamma irradiated at 77°K, were irradiated at 4.2°K and examined by electron spin resonance (ESR) at the same temperature. In each case an absorption was observed

that is probably due to trapped electrons. In three cases, the yield of trapped electrons at 4.2°K seemed to be as great as at 77°K. In one case, a glassy alkane, the yield was enhanced at 4.2°K. Trapped electrons in ethanol give a narrower ESR line at 4.2°K than at 77°K, suggesting less orientation in the solvent cage. Trapped hydrogen atoms were not detected after irradiation at 4.2°K. Contrary to prediction, hydrogen atoms were also not detected after post-irradiation photolysis of the trapped electrons. The results suggest that electron traps exist prior to irradiation and that molecular orientation via electronic dipole interaction is not a necessary condition for electron trapping. The results do not distinguish between trapping in solvent defects or trapping via electron-induced polarization of molecular orbitals. (auth) (Canada)

2119 USE OF ETHYLENE AS A GAS PHASE DOSIMETER FOR ACCELERATOR RADIATION. **Anderson, A. R.; Best, J. V. F. (Atomic Energy Research Establishment, Harwell, Eng.). Nature (London), 216: 576-7(Nov. 11, 1967).**

Previous dosimetry studies were extended by measuring the hydrogen yields from ethylene irradiated with ~1.5-MeV protons and with 4.3- and 6.8-MeV He ions, over a dose rate range from ~6×10^{18} to 6×10^{20} eV/g/sec. Irradiations were carried out at ambient temperature, and the evolved gases were analysed by gas chromatography after passage through a liquid nitrogen trap. Residual polymer on the walls of the irradiation cells had no effect on gas yields provided the vessel was not opened to air between irradiations. Experimental data are summarised graphically. Hydrogen production was a linear function of dose over the range 6×10^{18} to 6×10^{20} eV/g and over the LET range from about 1.1×10^{-3} eV/Å (1.5 MeV H^+) to about 7.1×10^{-3} eV/Å (4.3 MeV He^{2+}), at 20°C and 40 cm mercury. The average yield $G(H_2)$ was 1.31 ± 0.02. Results were in agreement with hydrogen formation principally by a molecular detachment process. The usefulness of ethylene as a simple gas phase dosimeter for work with accelerator beams was demonstrated. (UK)

2120 MECHANISM OF HYDROPEROXIDE FORMATION UNDER THE RADIATION-INDUCED OXIDATION OF n-HEPTANE AND n-NONANE (INFLUENCE OF TEMPERATURE AND DOSE INTENSITY). **Saraeva, V. V.; Pospelov, V. E.; Bakh, N. A. (Moscow State Univ.). Neftekhimiya, 7: 596-602(July-Aug. 1967). (In Russian).**

The radiation oxidation of n-heptane and n-nonane was investigated in the temperature interval from −78 to 140°. The presence of three temperature ranges during the formation of hydroperoxide was established: actual radiation range (from −78 to 0°) in which non-chain radical processes occur; radiation-thermal range (from 0 to 80°) in which unbranched chains were developed; and thermo-radiation range (80 to 140°) in which branched chain processes occur. The effect of the dose output (from 7.5×10^{13} up to 7.5×10^{15} ev/ml sec) on the process of the formation of hydroperoxide during the radiation oxidation of n-heptane and n-nonane was studied. An increase of the hydroperoxide yields with decrease of the dose output was found in the radiation-thermal and thermo-radiation ranges. A decrease in the dose output led to the displacement of the transition temperature from range I to range II and from range II to range III to the side of very low temperatures. (tr-auth)

2121 COMPARATIVE INVESTIGATIONS OF THERMAL AND RADIATION-INITIATED THERMAL CRACKING OF A GAS-OIL FRACTION. **Lavrovskii, K. P.; Florentsev, M. M.; Makarov, D. V.; Titov, V. B.; Aleksenko, Yu. N.; Fish, Yu. L. (Inst. of Petroleum-Chemical Synthesis, Moscow. Inst. of Atomic Energy, Moscow). Neftekhimiya, 7: 580-5(July-Aug. 1967). (In Russian).**

In comparative tests on radiation-thermal and thermal cracking of gas-oil fractions at temperatures of 500° and pressure of 40 kg/cm², it was found that, with the use of reactor radiation under conditions similar to industrial thermal cracking, the yield of gaseous products was not increased and the benzene fractions did not change their composition. At very low temperatures, the gas and benzene yields during radiation-thermal cracking were higher than at temperatures of thermal cracking, but the total conversion of gas-oil in these conditions was ~5 to 10%. (tr-auth)

2122 RADIATION INDUCED CONVERSION OF AMMONIUM THIOCYANATE TO THIOUREA. **Talreja, S. T.; Oza, P. M.; Rao, P. S. (Central Salt and Marine Chemicals Research Inst., Bhavnagar, India). Bull. Chem. Soc. Jap., 40: 2427-8(Oct. 1967).**

The effects of uv and γ radiation on isomerization of ammonium thiocyanate to thiourea were studied in an attempt to arrest the back reaction and increase the yield of thiourea. Data are presented in curves. (M.C.G.)

2123 PARAMAGNETIC RESONANCE IN GAMMA-IRRADIATED RONGALITE. **Mahadevappa, D. S.; Murthy, A. S. Ananda; Bharadwaj, I. S.; Devaprabhakara, D. (Dept. of Post-Graduate Studies and Research in Chemistry, Mysore, India). Curr. Sci. (India), 36: 573-4(Nov. 5, 1967).**

The ESR spectra of gamma-irradiated, microcrystalline rongalite, sodium formaldehydesulfoxylate, was compared with those previously reported for alkali thiosulfate and sodium thionite in order to study the formation of odd electron species during irradiation. Results indicated that the SO_3^- is probably not present in gamma-irradiated rongalite. It is suggested that the odd electron species in the irradiated rongalite are involved in considerable spin-orbit coupling. (J.G.B.)

2124 ELECTRON SPIN RESONANCE SPECTRUM OF $CH_3CO_2^{2-}$ TRAPPED IN γ-IRRADIATED SODIUM ACETATE. **Cadena, D. G. Jr.; Mendez, V.; Rowlands, J. R. (Southwest Research Inst., San Antonio). Mol. Phys., 13: 157-9(1967).**

The free radical $CH_3CO_2^{2-}$ was identified in γ-irradiated polycrystalline sodium acetate. The observed spectrum was compared with predictions based on simple Hückel calculations using the hetero atom model of the methyl group. (auth)

2125 PROTECTIVE EFFECTS OF AROMATIC AMINO ACIDS. **Grodskaya, G. A.; Ibragimov, A. P. (Inst. of Nuclear Physics, Tashkent). Dokl. Akad. Nauk Uzb. SSR, No. 7, 34-5 (1967). (In Russian).**

Radiation effects on glycine solutions (0.01, 0.05, and 0.5M in the presence of phenylalanine (0.001 to 0.05M) and tyrosine (0.004M aqueous solution and 0.01M in 1% HCl) was studied at 38°C with a dose rate of 450 RAD/sec of ^{60}Co γ-rays in nitrogen and oxygen at doses of 0.5×10^6 to 36×10^6 RAD. The results showed that additions of phenylalanine and tyrosine significantly reduced (30 to 70%) the general deamination of the glycine solutions. The yield of NH_3 from glycine and from glycine with various phenylalanine and tyrosine mixtures irradiated with doses up to 450 RAD/sec is tabulated. (R.V.J.)

2126 POLYMERIZATION OF ETHYLENE UNDER GAMMA RADIATION. III. KINETIC MODEL. **Dauphin, J. (Centre de Recherches, Gonfreville, France). Int. J. Appl. Radiat. Isotop., 18: 773-7(Nov. 1967). (In French).**

Experimental results given in the two preceding papers allowed the proposal of a model applicable to radioinduced polymerisation of ethylene. This model gives rise to some calculation possibilities the result of which seems to account fairly well for the main features of the reaction studied. The validity of the hypothesis made is, however, open to discussion. (auth) (UK)

2127 EFFECT OF HYDROGEN ATOM AND ELECTRON SCAVENGERS ON THE RADIOLYSIS OF AMMONIA GAS. **Johnson, G. R. A.; Simic, M. (Univ. of Newcastle-upon-Tyne, Eng.). Nature (London), 216: 479-80(Nov. 4, 1967).**

Ammonia gas is decomposed under the action of ionizing radiation to give only H_2 and N_2 in significant amounts. An investigation is described with the aim of determining the primary yield of H atoms in the radiolysis, and the contribution of ion neutralization to this yield. It was previously shown that the principal primary processes result ultimately in the formation of the radicals H and NH_2, and it can be assumed that the reactions of these species give rise to the H_2 and N_2 products. Since negative ions are formed only to a negligible extent in pure ammonia, the reaction of NH_4 ions with electrons is the main neutralization process. In order to measure the yield of H atoms, propane was used as scavenger. This reacts efficiently with free radicals, but not with the important intermediates NH_4 ions and electrons. ^{60}Co gamma irradiation was used in the studies, at a dose rate of 2×10^{15} eV/ml/min., in ammonia at 760 torr and 20°C. The temperature dependence of the H_2 and N_2 yields is shown graphically for pure ammonia, ammonia plus 1.5 mole % propane, and ammonia plus 0.3 mole % SF_6. The yields from pure ammonia were markedly dependent on temperature. In the presence of propane the N_2 yield was greatly decreased; the marked depression of the N_2 yield can be accounted for by reaction between the propane and NH_2 radicals. The H_2 yield was independent of temperature and propane concentration over the range 1.5 to 6 mole %. With propylene or benzene present (1.5 mole %) the H_2 yield fell to $G_{H_2} < 0.8$, and this suggests that the molecular yield is only a small fraction of the total primary yield. Addition of SF_6 to mixtures of ammonia and propane decreased the H_2 yield. The observation that total yield of H_2 from ammonia-propane mixtures, and the depression of this yield by SF_6, are independent of temperature strongly suggests that, at least over the range from 20 to 200°C, primary reactions leading to H-atoms in this system are not influenced by temperature. In the radiolysis of pure ammonia reactions of the

free radicals H with NH_2 can result either in the formation of H_2 and N_2, or in the re-formation of NH_3. It is suggested that the effect of temperature on the net decomposition of pure ammonia is the result of the competing reactions, involving H and NH_2, and possibly other intermediates formed from these radicals. This competition favors the re-formation of ammonia at low temperatures, and the formation of H_2 and N_2 at high temperatures. (UK)

2128 TO THE THEORY OF RADIATION CHEMISTRY. IV. THE CALCULATION OF RADIATION–CHEMICAL YIELDS IN THE RADIOLYSIS OF METHANE, ETHANE, PROPANE, AND METHANOL IN THE GAS PHASE. Prasil, Z. (Inst. of Nuclear Research, Czechoslovak Academy of Sciences, Rez). Collect. Czech. Chem. Commun., 32: 3105-32(Sept. 1967).

General considerations about the application of the theory of unimolecular reactions and of the theory of mass spectra were applied to the calculation of relative radiation–chemical yields of products in the radiolysis of methane, ethane, propane, and methanol in the gas phase. A good agreement between calculated and experimental results, both for mass spectra and breakdown curves, as well as for relative radiation–chemical yields was achieved with semiempirically determined parameters and distribution functions for excited states. (auth)

2129 RADIATION AND PHOTOCHEMISTRY. Ausloos, P. (National Bureau of Standards, Washington, D. C.). Ann. Rev. Phys. Chem., 17: 205-36(1966).

A review is presented on radiation and photochemistry. Topics discussed include: experimental techniques; ion-molecule reactions; fragmentation of the parent ion; neutralization; decomposition and reactions of neutral excited molecules, electronically excited molecules in radiolysis; and electronic excitation energy transfer. (207 references). (P.C.H.)

2130 RADIATION CHEMISTRY OF GASEOUS AMMONIA. PART 1. RADICAL AND MOLECULAR PRODUCT YIELDS. Jones, F. T.; Sworski, T. J. (Union Carbide Corp., Tuxedo, N. Y.). Trans. Faraday Soc., 63: 2411-25(Oct. 1967).

The effects of temperature and various additives were studied in the 1.0-MeV electron radiolysis of gaseous ammonia. A non-scavengable hydrogen yield of $G_{H_2} = 0.75 \pm 0.05$ was obtained in ethylene + ammonia mixtures, and an H-atom yield of $G_H = 12.5 \pm 1.0$ was obtained in hydrazine + ammonia mixtures at 23°C, consistent with results in deuterium + ammonia mixtures at low NH_3 pressures. Product yields in pure ammonia increased with increasing temperature up to limiting values obtained at 300°C and above. The primary decomposition yield of $G_{-NH_3} = 15.1$ at 300°C was larger than the yield $G_{-NH_3} = 14.0$ at 23°C. Large amounts of HD were produced by a chain mechanism in the radiolysis of $D_2 + NH_3$ mixtures at 200°C. (auth)

2131 RADIATION CHEMISTRY OF GASEOUS AMMONIA. PART 2. HYDRAZINE FORMATION. Jones, F. T.; Sworski, T. J.; Williams, J. M. (Union Carbide Corp., Tuxedo, N. Y.). Trans. Faraday Soc., 63: 2426-34(Oct. 1967).

The radiolysis of gaseous NH_3 with 1.0-MeV electrons was investigated both in a static system as a function of radiation intensity and in a flow system as a function of flow rate, intensity, and temperature. The effects of flow rate, pressure, and radiation intensity were qualitatively similar to those reported by McDonald, Kahn, and Gunning for photochemical decomposition of NH_3 in a flow system. At a constant flow rate and radiation intensity, N_2H_4 yields increased with increase in temperature, with $G(N_2H_4) = 17.0 \exp(-1980/RT)$. An upper limit of $G(-NH_3) = 34.0$ is indicated when all H atoms are scavenged by NH_3 and all NH_2 radicals combine to form N_2H_4. Lower $G(-NH_3)$ values are observed under attainable conditions due to NH_3 reformation reactions of NH_2 with N_2H_4. (auth) (UK)

2132 RADIATION-INDUCED FORMATION OF TETRAMERIC HYDROGEN CYANIDE IN AN AQUEOUS SOLUTION. Ogura, Hajime; Kondo, Masaharu (Tokyo Metropolitan Univ.). Bull. Chem. Soc. Jap., 40: 2448-9(1967).

Radioinduced formation of the tetrameric form of hydrogen cyanide in a dilute aqueous solution was investigated by means of uv spectroscopy and paper chromotography. Gamma irradiation was carried out with a ^{60}Co source at a dose rate of 2.90×10^{17} eV ml^{-1} hr^{-1}. (M.C.G.)

2133 RADIOLYSIS OF SUCCINIC ACID IN AQUEOUS SOLUTION. Tanaka, F.; Wang, C. H. (Oregon State Univ., Corvallis). Int. J. Appl. Radiat. Isotop., 18: 761-72(Nov. 1967).

The radiolysis of succinic acid in aqueous solutions induced by gamma irradiation from a ^{60}Co source was studied with respect to the identification and estimation of degradation products. Specifically labeled succinic acid-^{14}C and malic acid-^{14}C were utilized for product identification and elucidation of reaction mechanisms. The irradiation experiments were performed under both oxygenated and oxygen-free environments. The principal means of identification of the radiolytic products were by paper chromatography and autoradiography, utilizing the technique of cochromatography. The estimation of each radiolytic product was by radiochemical assay using liquid scintillation counting techniques. The finding that malonic acid is a major product of radiolysis of succinic acid is of considerable interest. A reaction mechanism is proposed for the radiolytic conversion of succinic acid to malonic acid via the intermediary formation of malate and oxaloacetate. (auth) (UK)

2134 PULSE RADIOLYSIS OF NITROBENZENE SOLUTIONS. Asmus, K.-D.; Cercek, B.; Ebert, M.; Henglein, A.; Wigger, A. (Hahn-Meitner-Institut fuer Kernforschung, Berlin. Christie Hospital and Holt Radium Inst., Manchester, Eng.). Trans. Faraday Soc., 63: 2435-41(Oct. 1967).

The absorption spectra of the radicals $HC_6H_5NO_2$ and $OHC_6H_5NO_2$ in aqueous solutions were obtained. These transients have a strong absorption at 4100 Å and their molar extinction coefficients are both 3700 M^{-1} cm^{-1}. The following rate constants were measured: $k(H + C_6H_5NO_2) = (5.6 \pm 0.6) \times 10^9$ M^{-1} sec^{-1}; $k(OH + C_6H_5NO_2) = (4.7 \pm 0.5) \times 10^9$ M^{-1} sec^{-1}; $k(O_2 + OHC_6H_5NO_2) = (2.3 \pm 0.3) \times 10^6$ M^{-1} sec^{-1}; $k(OHC_6H_5NO_2 + OHC_6H_5NO_2) = 6.0 \pm 0.4) \times 10^8$ M^{-1} sec^{-1}. About 25% of the reactions between two nitro hydroxycyclohexadienylradicals lead to nitrophenol isomers by disproportionation. The majority of these reactions lead to other products (probably dimers by combination) that exist in acid and basic forms, the latter having strong absorptions in the visible range. These products are believed to be derivatives of nitro cyclohexadiene. (auth) (UK)

2135 OBTAINING ^{99m}Tc FROM ^{99}Mo-CONTAINING AMMONIUM MOLYBDATOPHOSPHATE. Levi, H. W.; Reichold, P.; Wolf, P. (Hahn-Meitner-Institut fuer Kernforschung, Berlin). Radiochim. Acta, 7: 168(June 1967). (In German).

The use of an ammonium molybdatophosphate column for elution separation of ^{99m}Tc was investigated. The column was eluted with isotonic NaCl or isotonic NH_4Cl. In both cases significant amounts of ^{99}Mo were obtained. The NH_4Cl extract contained the lowest Mo concentration and the ^{99}Tc had a purity of approximately 97%. If this extractant was passed through an Al_2O_3 column, the purity was increased to 99.9%. Observations made over the period of a week show that the purity and the activity yield varied only slightly. (J.S.R.)

2136 WHAT IS RADIATION CHEMISTRY? Roberts, R. (United Kingdom Atomic Energy Authority, Wantage, Eng.). J. Brit. Nucl. Energy Soc., 6: 295-300(Oct. 1967).

The scope of radiation chemistry is defined and the various reaction mechanisms are discussed. Industrial applications of the reactions are considered. (UK)

2137 THE TRANSITION OF RADIATION CHEMISTRY TO AN INDUSTRIAL REALITY: THE DOW ETHYL BROMIDE PROCESS. Harmer, David E. (Dow Chemical Co., Midland, Mich.). J. Brit. Nucl. Energy Soc., 6: 320-9(Oct. 1967).

The various steps in the transition of radiation chemistry from the fundamental research stage to the practicality of chemical production are examined, with particular attention to the ethyl bromide process. The process is followed from its inception as an idea, through the initial laboratory work, through a prototype operation, and finally into the plant. Factors influencing the selection of the process are discussed. Methods of calculation for the projection of laboratory data to a full-scale process are outlined. Finally, those characteristics of high-energy radiation that could make it of special value to industry are explored. (auth) (UK)

2138 GAMMA RADIATION PLANT: ECONOMIC ASSESSMENTS. Bailey, P. J.; Baines, B. D.; Spalding, E. G. (Nuclear Chemical Plant Co. Ltd., Ealing, Eng.). J. Brit. Nucl. Energy Soc., 6: 330-6(Oct. 1967).

Industrial applications of radiation chemistry are limited by several criteria that must be met before any such application can be economically attractive. Reactions of interest are outlined, and a range of equipment is described, with comments on costs and features of design resulting from the use of radioactive sources. One reaction examined is the production of benzene hexachloride using ^{60}Co γ radiation as compared with ultraviolet radiation. A suitable plant for the ^{60}Co process is described, and a comparison of costs is given for the two processes, indicating an advantage for ^{60}Co. (auth) (UK)

2139 INTERACTION OF LOW-ENERGY ELECTRONS WITH POLYATOMIC MOLECULES. Christophorou, L. G.; Compton, R. N. (Oak Ridge National Lab., Tenn.). Contract W-7405-eng-26. Health Phys., 13: 1277-1305(Dec. 1967). (ORNL-P-2938).

The interactions of low-energy electrons with polyatomic mole-

cules are reviewed briefly. Results obtained on electron diffusion, elastic and inelastic electron scattering, excitation of molecules by electron impact, and electron capture by molecules are discussed. Tables of electron capture cross sections and electron affinities for polyatomic molecules are included. The importance of low-energy electron interactions with polyatomic molecules to the radiation sciences is stressed. (auth) (UK)

2140 COATINGS AND WOOD PLASTICS: [RADIATION CURING]. Dalton, F. L. (United Kingdom Atomic Energy Authority, Wantage, Eng.). J. Brit. Nucl. Energy Soc., 6: 305-9(Oct. 1967).

A survey is presented of the application of 150- to 500-kV electron accelerators to the treatment of thin films and surface coatings. The advantages of radiation curing are enumerated and costs estimated. In addition to polyester paints, other suitable compositions are discussed. The curing of monomer-impregnated wood by chemical methods and by high-energy radiation is compared, and developments in this field are reviewed. It was concluded that the production costs and market value of wood plastic have not yet established the process as a commercial proposition. (UK)

2141 EFFECTS OF PHASE HOMOGENEITY ON THE CHEMICAL CONSEQUENCES OF NUCLEAR REACTIONS. Stevovic, J.; Tanaka, K.; Milman, M. (CEA, Gifs-sur-Yvette, France). Inorg. Nucl. Chem. Lett., 3: 415-18(Oct. 1967).

An attempt is made to correlate the effects of radiative neutron capture in solid binary mixtures containing bromine with the relative homogeneity of the phases. Quickly frozen polycrystalline samples of bromoform and bromine, and of benzene and bromine, were exposed for 1 sec at –196°C to a thermal neutron flux of 10^{12} n/cm^2/sec. After extraction of the inorganic halogen the percentage yield of organically bound ^{80m}Br was determined in the usual way. Phase diagrams of the mixtures irradiated were obtained. In the case of bromoform/benzene the equilibrium diagram has one eutectic point. For bromine concentrations smaller than corresponding to the eutectic point the sample will contain zones of pure bromoform and of eutectic mixture. For higher concentrations pure bromine and eutectic mixture will be deposited. The plot of the organic yield of ^{80m}Br as a function of bromine concentration showed two linear sections, with a change of slope in the eutectic region. The first part of the curve reflected the linear summation of two organic yields, corresponding to pure halide and eutectic mixture, while the second part corresponded to progressive diminution of eutectic mixture due to increasing concentration of pure halogen grains. It seems that for this system the dimensions of the halide and halogen grains inside the eutectic grains are small, the boundary surface becomes relatively important, and chemical interaction between grains is probable. In the case of benzene and bromine the phase diagram has two eutectics and shows formation of the 1:1 complex. Phases consist of pure benzene and eutectic, the eutectic itself being a mixture of pure benzene and complex. Data on the organic yield indicate that the fate of the ^{80m}Br atom in this system is settled in an environment of constant composition, namely, that of the benzene-bromine complex. For high concentrations of bromine the nature and composition of the eutectic mixture changes, and the presence of an increasing number of pure halogen grains causes linear decrease of the organic yield. (UK)

2142 RADIATION CHEMISTRY OF CYSTAMINE SULPHATE. Jayson, G. G.; Owen, T. C.; Wilbraham, A. C. (Liverpool Regional College of Tech.). J. Chem. Soc., B, No. 10, 944-9(1967).

Irradiation of aqueous cystamine solutions with x rays (230 kV; 15 mA), in the presence of oxygen, resulted in the formation of taurine, hydrogen, peroxide, and traces of hydrogen sulfide. When oxygen was removed from the solution, hydrogen sulfide formation increased noticeably, while yields of taurine and peroxide both decreased. The dependence of radiation yields on pH, and on the initial concentrations of cystamine, hydrogen peroxide, and dissolved oxygen were studied. The primary action on the cystamine molecule most probably is attack by ·OH, with contributions from attack by ·H and by ·O_2H under favorable conditions. Hydrogen peroxide ·O_2^- and e^-_{aq}, probably do not react readily with cystamine. The results suggest that the successful radiation-protective properties of cystamine may be due to its dual capacity of radical acceptor and oxygen scavenger. (auth) (UK)

2143 POSSIBLE EXPLANATION OF THE PROTECTIVE ACTION OF POLYANIONS AND CYSTEINE IN RADIOLYSIS BASED ON THE MECHANISM OF ENERGY TRANSFER. Yermolaev, V. K.; Cherepanov, V. Yu.; Berdyshev, G. D.; Molin, Yu. N; Salganik, R. I. (Inst. of Chemical Kinetics and Combustion, Novosibirsk, USSR. Inst. of Cytology and Genetics, Novosibirsk, USSR). Biophysics (USSR)(Engl. Transl.), 11: 924-9(1966).

Translation of Biofizika, 11: 805-9(1966).

The EPR method was used to study the radiolysis of mixtures of polyanions (chondroitin sulfate, hyaluronic acid) and cysteine with RNA and trypsin at 77°K. It was found that the energy of the ionizing radiations absorbed by the polyanions and cysteine is transferred to the molecules of RNA and trypsin. Evidently, the mechanism of the protective effect of cysteine and polyanions can not be explained by transfer to the molecules of these substances of the energy absorbed by the biopolymers — protein and RNA. (auth)

2144 COMPARATIVE DESCRIPTION OF RADICAL STATES APPEARING IN CRYSTALLINE TRYPSIN ON IRRADIATION WITH 660 MeV PROTONS AND GAMMA QUANTA. Gaponova, I. S.; Ginsburg, S. F.; Postnikova, N. S. (Biophysics (USSR)Engl. Transl.), 11: 1044-6(1966).

Translation of Biofizika, 11: 909-10(1966).

EPR measurements were used to investigate the radical states appearing on irradiation of crystalline trypsin. The concentration and spatial distribution of the radicals was determined. Results indicated that the radicals formed on irradiation with ^{60}Co γ-quanta and 660 MeV protons do not differ significantly in structure and patterns of accumulation. (J.G.B.)

2145 DESTRUCTION OF DILUTE ORGANIC POLLUTANTS BY GAMMA IRRADIATION. Condron, A. J.; Etzel, J. E. (Purdue Univ., Lafayette, Ind.). Effluent Water Treat. J., 7: 528-32 (Oct. 1967).

The application of radiation chemistry principles to the correction of some water pollution difficulties is discussed, and research is described with a view to exploring the possible use of gamma irradiation as a means of achieving a higher degree of waste water treatment than is currently possible with existing facilities. The experimental work was concerned mainly with the effects of certain variables (radiation dose, waste concentration, H_2O_2 and O_2 concentrations) on the attainable amount of organic residue destruction. Results are discussed in terms of chemical oxygen demand. (UK)

2146 GAMMA RADIOLYSIS OF ETHYLTOLUENE. Weiss, Jerome; Rao, Hanumantha M. (Brookhaven National Lab., Upton, New York). Radiat. Res., 32: 309-13(1967). (BNL-10861).

The gamma radiolysis of the three isomers of ethyltoluene was investigated in the liquid state. The effect of temperature and added oxygen on the gas yields was also studied. From the gas yields it is seen that order of radiation stability is m > p > 0. p-Ethyltoluene deuterated in the methyl group was irradiated in an attempt to determine the origin of the methane and the C_2 hydrocarbons. The data indicate that at least 90% of the gases produced originate from the ethyl group of the molecule. (auth)

2147 AMINO ACID RADICALS PRODUCED CHEMICALLY IN AQUEOUS SOLUTIONS. ELECTRON SPIN RESONANCE SPECTRA AND RELATION TO RADIOLYSIS PRODUCTS. Armstrong, W. A.; Humphreys, W. G. (Defence Research Board, Ottawa). Can. J. Chem., 45: 2589-99(Nov. 1967).

Amino acid radicals were generated by the reaction of titanium trichloride with hydrogen peroxide in the presence of an amino acid, and were identified by electron spin resonance spectroscopy. An amino acid analyzer was used to show that the products of this reaction were the same as those of the corresponding γ-irradiated, oxygenated aqueous amino acid solution. Cysteine, cystine, and homocystine gave identical spectra which were attributed to RCH_2S· radicals, whereas penicillamine gave $RC(CH_3)_2S$· radicals. Most other amino acid radicals were formed by the abstraction of a hydrogen atom from the C_2 position (numbered from the amino group). This was true for dl-α-alanine, β-alanine, taurine, dl-aspartic acid, α-aminoisobutyric acid, dl-serine, and dl-valine, although with valine a lower concentration of the radical resulting from the removal of a hydrogen atom from C_3 was also observed. Abstraction from the C_3 position also occurred with dl-threonine. These facts are consistent with the view that the strong negative inductive effect of the NH_3^+ group deactivates the neighboring C–H bond towards attack by the electrophilic hydroxyl radical. Glycine formed one radical by the loss of a hydrogen atom from the C_1 position, and a second by deamination. (auth) (UK)

2148 THE CHEMISTRY OF IONISATION AND EXCITATION. Proceedings of Conference on Radiation Chemistry and Photochemistry, University of Newcastle upon Tyne, England, 21–23 Sept. 1966. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967. 328p. 80s. (CONF-660955). DTIE.

The Conference, which was held under the auspices of the North of England Council of the British Empire Cancer Campaign, included 28 papers. Separate abstracts were prepared for 22 of these papers. Papers dealing purely with photochemistry were not abstracted. (UK)

For abstracts of individual papers see: 2084–2086 and 2149–2167.

2149 INTRODUCTORY PAPER. Dainton, F. S. (Univ. of Leeds, Eng.). pp 3-15 of Chemistry of Ionisation and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21-23, 1966. See CONF-660955.

The similarities and differences between radiation and photochemical primary processes are discussed and also data relating to some of the intermediates that were studied most. Recent results obtained are also presented. Topics discussed are: primary processes; similarities and differences (the energy-absorption mechanism, comparison of primary species, additional effects due to the presence of neighboring molecules); summary of information concerning the two principal primary species in the radiolysis of condensed polar systems (the electron, the hydroxyl radical); and species formed by the addition of e^-_{aq}, H, OH, and CH_3CHOH to double bonds. (UK)

2150 ELECTRON-TRANSFER PROCESSES IN RADIATION-INDUCED REACTIONS. Weiss, J. J. (Univ. of Newcastle upon Tyne, Eng.). pp 17-23 of Chemistry of Ionisation and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21-23, 1966. See CONF-660955.

Earlier work on electron-transfer processes in the quenching of fluorescence and related photosensitized reactions, e.g. the photochemical formation of peroxides and nitroxides, and some dye-sensitized reactions, is briefly reviewed. Electron transfer in the formation and reactions of radiation-produced trapped holes in ice matrices is discussed with particular reference to SO_4^- and HPO_4^- radical ions. New results are presented concerning the photochemistry of simple ions in solutions. These lead to the conclusion that in the case of negative ions, in addition to the primary formation of a short-lived photo-excited state, a relatively long-lived intermediate is formed where the electron (polaron) is trapped in the field of its original center. Studies of the kinetic salt effect in the photochemistry of ferrous ions showed that it is photo-excited ferrous ion itself which is the reacting entity. (auth) (UK)

2151 EXCITATION AND IONIZATION. SOME CORRELATIONS BETWEEN THE PHOTO AND RADIATION CHEMISTRY OF LIQUIDS. Stein, G. (Hebrew Univ., Jerusalem). pp 25-34 of Chemistry of Ionisation and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21-23, 1966. See CONF-660955.

The experimental results obtained in the photo- and radiation chemistry of solutions in water and benzene respectively are surveyed and compared. The mechanisms that lead, in the radiation chemistry of water, to relatively small contributions by excited states, and in the case of benzene solutions to relatively large participation, are discussed in terms of the molecular structure of the solvent. Conditions under which the contribution of excitation processes in aqueous solutions may increase are discussed. (auth) (UK)

2152 SCAVENGING OF SMALL RADICALS BY NITRIC OXIDE. Kohout, F. C.; Maschke, A.; Lampe, F. W. (Pennsylvania State Univ., University Park). pp 51-9 of Chemistry of Ionisation and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21-23, 1966. See CONF-660955.

The reactions of methyl radicals and hydrogen atoms with nitric oxide under the usual scavenging conditions of low nitric oxide concentration are discussed. In both cases the initial reaction is the formation of the nitroso compound, RNO. In the case of methyl radicals, dimerization of CH_3NO and "chaperon" formation of ethane, via reaction of CH_3NO with CH_3, cannot compete with further addition of CH_3 to form trimethylhydroxylamine. In the case of hydrogen atoms, the "chaperon" recombination of hydrogen atoms, via attack of H on HNO, must occur readily. However, combination of HNO molecules to form N_2O and H_2O is also very fast. At the pressures employed further addition of H atoms to form hydroxylamine was also observed. Rate constants for some of the processes are given. (auth) (UK)

2153 γ RADIOLYSIS OF ISOPROPANOL + BENZOPHENONE MIXTURES. von Sonntag, C.; Land, G.; Schulte-Frohlinde, D. (Kernforschungszentrum, Karlsruhe, Ger.). pp 123-30 of Chemistry of Ionization and Excitation. Johnson, G. R. A.; Scholes, G. (eds). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21-23, 1966. See CONF-660955.

Hydrogen, acetone, methane, and acetaldehyde are the main products of the γ-radiolysis of isopropanol. The effect of added benzophenone and p-hydroxybenzophenone on the G values of these products was studied in the range of 1 to 15% additive; G(methane) and G(acetaldehyde) were not altered; $G(H_2)$ decreased markedly. For these products there was difference whether benzophenone or p-hydroxybenzophenone was used as an additive. The yields of acetone, however, were different in the two cases, more being formed in the presence of benzophenone. The excess of acetone in the latter case is attributed to the reaction of electronically excited benzophenone with isopropanol. The mode of excitation is discussed. (auth) (UK)

2154 RADIOLYSIS AND PHOTOLYSIS OF NITROMETHANE. Cundall, R. B.; Locke, A. W.; Street, G. C. (Univ. of Nottingham, Eng.). pp 131-40 of Chemistry of Ionisation and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21-23, 1966. See CONF-660955.

Experimental results on the radiolysis of nitromethane by γ rays and electrons are presented. The photolysis by uv light at 2537 and 3130 Å was also examined. In the photolytic system methyl nitrite, formed by the cage effect, is the major product, although the formation of nitrosomethane and other products shows that methoxy radicals and nitric oxide must be formed by ill-defined processes. Photolysis of the reaction products may be a complicating feature. The wider range of products in the radiolytic system is taken as evidence for ionic processes. (auth) (UK)

2155 RARE-GAS SENSITIZED RADIOLYSIS OF LIQUID PROPANE. Koob, R. D.; Kevan, L. (Univ. of Kansas, Lawrence). pp 141-50 of Chemistry of Ionisation and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21-23, 1966. See CONF-660955.

The rare gas-sensitized radiolysis of liquid propane with argon, krypton, and xenon was examined in the presence of radical scavengers. It was demonstrated that energy is transferred from the rare gas mainly by charge transfer. Charge transfer occurs from the dimeric rare gas ion to produce the ionic fragmentation products, methane and ethane. Ion neutralization produces the molecular decomposition products, ethylene and propylene. As the rare gas is changed from Ar to Kr to Xe the ionic fragmentation products become relatively less important and the molecular fragmentation products become relatively more important. Two specific ionic fragmentation reactions of the parent propane ion to give $C_2H_5^+$ and $C_3H_7^+$ were demonstrated by isotopic labelling. $C_3H_7^+$ was shown to undergo efficient hydride-ion transfer to form C_3H_8 in the liquid mixture. Other evidence implies that $C_3H_7^+$ may react with propane to produce ultimately n-pentane. (auth) (UK)

2156 ELECTRON-ATTACHMENT PROCESSES IN IR-RADIATED ORGANIC LIQUIDS. Munday, C. S.; Richards, J. T.; Scholes, G.; Simic, M. (Univ. of Newcastle upon Tyne, Eng.). pp 151-61 of Chemistry of Ionisation and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21-23, 1966. See CONF-660955.

Cyclohexane was irradiated with γ rays in the presence of various electron scavengers known to have a low reactivity towards hydrogen atoms (CO_2, SF_6, N_2O). The effects of these additives on the hydrogen yields and, in the case of N_2O solutions, the production of nitrogen, were investigated. The radiolysis of cyclohexane solutions of deuterated halogen acids was studied (particularly using DCl) and the isotopic composition of gaseous products determined. The results, in general, confirm the concept of the occurrence of electron-attachment processes in the irradiation of this non-polar solvent. The relationship between the extent of attachment and the yields of nitrogen in the cyclohexane + N_2O system is discussed. The effects of N_2O and of $N_2O + H_2S$ in the radiolysis of some aliphatic alcohols (ethanol, isopropanol) are described and are also discussed in terms of electron scavenging in these solvents. (auth) (UK)

2157 RADIATION-INDUCED INCORPORATION OF NITRIC OXIDE INTO ORGANIC COMPOUNDS. Horacek, K.; Getoff, N.; Schenck, G. O. (Max-Planck-Institut fuer Kohlenforschung, Muelheim, Ger.). pp 178-9 of Chemistry of Ionisation and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21–23, 1966. See CONF-660955.

The radioinduced incorporation of NO into cyclohexane and toluene was studied. The products formed were identified by gas chromatography, ir and NMR spectroscopy. From the cyclohexane + NO system these were found to be cyclohexanone oxime, cyclohexanone, cyclohexanol, cyclohexyl nitrite, nitrocyclohexane, dicyclohexyl, and adipic acid. The nature of the radioinduced incorporation is discussed. In the case of toluene, products included benzaldehyde and benzyl nitrite, plus a dark brown viscous oil that is under investigation. (auth) (UK)

2158 THE EFFECT OF TEMPERATURE AND PRESSURE ON THE VAPOUR PHASE γ-RADIOLYSIS OF SOME POLAR MOLECULES. Anderson, A. R.; Winter, J. A. (Atomic Energy Research Establishment, Harwell, Eng.). pp 197-209 of Chemistry of Ionization and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21–23, 1966. See CONF-660955.

The effect of temperature on yields in the γ-radiolysis of water vapor was attributed to a change in stability of ion–molecule clusters, leading to quantitative differences on charge neutralization. Similar effects were also observed with other polar molecules, viz. CH_3OH, C_2H_5OH, n-C_3H_7OH and NH_3. The general ion–molecule equilibrium is represented by: $ROH_2^+(ROH)_n \rightleftharpoons ROH_2^+(ROH)_{n-m} + mROH$ and it is suggested that charge neutralization of the two different ions can lead to different yields of given products, e.g. H_2, CH_4. Moreover, the data indicate that C–C bond fission occurs in addition to C–H bond fission on charge neutralization of ions derived from the alcohols, and that the relative proportions of these bond ruptures may depend on temperature and on the nature of the negative ion. Lower limits for the heats of solvation of the ions ROH_2^+ in the vapor phase, derived from the experimental data, approach values obtained from the literature. While high temperatures and low pressures displace the equilibrium represented by the above equation to the right-hand side, lowering the vapor pressure in a given geometry leads to additional increases in measured yields. These increases are connected, at least in part, with wall effects but insufficient data were obtained to suggest a mechanism. (auth) (UK)

2159 EXCITATION AND IONIZATION IN THE RADIOLYSIS OF WATER VAPOUR. H/D ISOTOPE EFFECT IN THE FORMATION OF HYDROGEN ATOMS. Johnson, G. R. A.; Simic, M. (Univ. of Newcastle upon Tyne, Eng.). pp 211-16 of Chemistry of Ionisation and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21–23, 1966. See CONF-660955.

In irradiated D_2O vapor, D atoms are produced by hydronium ion + electron neutralization with $G(D)_{hydronium} = 2.7 \pm 0.6$. D atoms are also produced by another ("residual") process with $G(D)_{residual} = 4.9 \pm 0.5$. Electron scavengers ($N_2O$, SF_6, O_2, CH_3Br) supress the formation of D atoms from hydronium ions so that only the D atoms from the residual process are observed. The use of electron scavengers, therefore, provides a technique by which the hydrogen atoms formed by the two different processes can be distinguished. Using C_3H_8 as hydrogen atom scavenger, the separation factor $\alpha = (H/D)_{product}/(H/D)_{water}$ was determined for a range of $H_2O + D_2O$ mixtures, in the presence and absence of SF_6. The separation factors for hydrogen atoms from hydronium ion neutralization and from the residual processes were 2.1 ± 0.4 and $1.1 + 0.2$, respectively. It is considered that the residual process involves mainly the decomposition of excited water molecules, with an equal probability of O–H and O–D bond breakage. The isotope effect in the formation of hydrogen atoms from hydronium ions is discussed. The yield of D_2 from $H_2O + D_2O$ mixtures was directly proportional to the mole fraction of D_2O, showing that the molecular hydrogen originates from a single water molecule. (auth) (UK)

2160 THEORY OF PRIMARY RADIATION-CHEMICAL YIELD. Santar, I.; Bednar, J. (Inst. of Nuclear Research, Czechoslovak Academy of Sciences, Rez). pp 217-22 of Chemistry of Ionisation and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21–23, 1966. See CONF-660955.

Theoretical methods for estimating the yields of primary activations in the action of ionizing radiation on matter, due primarily to Platzman, are discussed. A possible approach to calculation of the yield of excitations and ionizations of valence electrons, which represent the bulk of primary activations, is suggested, consisting essentially of treating separately the contributions of "fast" and "slow" electrons of the degradation spectrum. (auth) (UK)

2161 RADIATION CHEMISTRY OF PROPANE. Bone, L. I.; Sieck, L. W.; Futrell, J. H. (Aerospace Research Labs., Wright-Patterson AFB, Ohio). pp 223-35 of Chemistry of Ionisation and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21–23, 1966. See CONF-660955.

Ionic fragmentation patterns were deduced for xenon- and krypton-sensitized radiolysis and for direct radiolysis of propane. Ion-titration techniques were used to measure and characterize unreactive ions in these systems, and a neutralization scheme was advanced for these ions. Decomposition schemes for excited neutral propane molecules were deduced from related experiments and incorporated into a formulation of a complete mechanism for the radiolytic decomposition of propane. Based on the present results it is suggested that the conversion dependence observed in earlier studies of gas-phase radiolysis of alkanes is related to ion interception rather than to free-radical scavenging. (auth) (UK)

2162 THE EFFECT OF METHANE ON THE RATE OF EXCHANGE OF ^{14}C BETWEEN CO AND CO_2 UNDER RADIATION. Dominey, D. A.; Morley, H.; Sharpe, B. P. K.; Waite, R. J. (Atomic Energy Research Establishment, Harwell, Eng.). pp 237-44 of Chemistry of Ionisation and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21–23, 1966. See CONF-660955.

The effect of CH_4 was studied on the γ-induced exchange of ^{14}C between CO and CO_2 using both ^{14}CO and $^{14}CO_2$. CH_4 had only a small effect on the rate of production of ^{14}CO from $^{14}CO_2$ but had a much larger effect on the rate of production of $^{14}CO_2$ from ^{14}CO, this difference being larger at an irradiation temperature of 375°C than at 33°C. These results, together with the observed values of $G(CO)$ and $G(-CH_4)$ for different gas mixtures irradiated at 33°C and 375°C, can largely be explained by competition between CH_4 and CO for reaction with an active species produced by the radiolysis of CO_2. (auth) (UK)

2163 NATURE OF THE PRECURSOR OF MOLECULAR HYDROGEN IN THE RADIOLYSIS OF WATER. Mahlman, H. A.; Sworski, T. J. (Oak Ridge National Lab., Tenn.). pp 259-67 of Chemistry of Ionisation and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21–23, 1966. See CONF-660955.

The most widely accepted theory for the radiolysis of water is the diffusion–kinetic theory of Samuel and Magee. Following the discovery of e^-_{aq} as the principal reducing species in water, it became common to assume that H_3O^+, e^-_{aq} and OH were the primary chemical species in the spur and that e^-_{aq} was the principal precursor of H_2. An absence of pH effects on the reaction of solute with the precursor of H_2 is reported that is inconsistent with these assumptions. It is consistent, however, with the conclusion of Platzman that the initial gaussian distribution for e^-_{aq} is probably greater than a 50 Å diameter, too large for e^-_{aq} to contribute significantly to H_2 formation. It is also consistent with the conclusions of Sworski that H_3O and "excited water" are precursors of H_2. (auth) (UK)

2164 HYDROGEN ATOM YIELD IN IRRADIATED AQUEOUS SOLUTION. Appleby, A. (Brookhaven National Lab., Upton, N. Y.). pp 269-75 of Chemistry of Ionisation and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21–23, 1966. See CONF-660955.

The possible formation of at least part of the independent yield of hydrogen atoms in irradiated aqueous solution by a spur process involving solvated electrons and hydrogen ions is considered. Evidence is presented that solutes reactive towards electrons or hydrogen ions are effective in lowering the observed hydrogen atom yield. (auth) (UK)

2165 γ-RADIOLYSIS OF AQUEOUS SOLUTIONS OF TELLURIUM. II. PRELIMINARY RESULTS ON ACID SOLUTIONS. Haissinsky, M. (Laboratoire Curie, Paris). pp 277–80 of Chemistry of Ionization and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21–23, 1966. See CONF-660955.

In oxygenated 0.8N sulphuric acid solution tellurous acid was oxidized by γ rays to telluric acid with a yield that increased with solute concentration; hydrogen peroxide was simultaneously formed. From the observed yields, and knowing $k_{(HO_2+HO_2)}$, the rate constant of the reaction between Te^{IV} and HO_2 was determined. In degassed solution Te^{IV} was oxidized to Te^{VI}, but the latter was also reduced to Te^{IV}, the yield being very small in both cases and a stationary state was established after prolonged irradiation. The formation of H_2O_2, H_2, and O_2 was also observed. By the addition of H_2O_2 to oxygenated solutions of Te^{IV}, or to degassed solutions of Te^{IV}, it was possible to calculate the rate constants $k_{(Te^{IV}+OH)}$ and $k_{(Te^{IV}+H)}$. (auth) (UK)

2166 THE PULSE RADIOLYSIS OF SULPHUR COMPOUNDS. PART I. CYSTEAMINE AND CYSTAMINE. Adams, G. E.; McNaughton, G. S.; Michael, B. D. (Mount Vernon Hospital, Northwood, Eng.). pp 281-93 of Chemistry of Ionisation and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21–23, 1966. See CONF-660955.

Irradiation of cysteamine solutions by a 0.2 μsec electron pulse produced a transient species that absorbed strongly at 4100 Å. The spectrum was assigned to a complex form of the cysteamyl radical that arises from a reaction of OH with the solute: OH + RSH → RS + H_2O. The RS radical complexes with another solute molecule according to the equilibrium: RS + RS ⇌ $RSSR^-$. The ion $RSSR^-$ was formed directly by electron attachment during irradiation of deaerated solutions of the corresponding disulphide, cystamine (RSSR): RSSR + e^-_{aq} → $RSSR^-$. In N_2O-saturated solutions of cysteamine, the concentration of the complex $RSSR^-$ produced during the pulse was very dependent upon both pH and cysteamine concentration. Under all conditions, except at pH 11, the absorption decayed according to second-order kinetics, although the rate constant for the process was very dependent upon pH. In deaerated cystamine solutions, however, the absorption disappeared exponentially within a few microseconds after the pulse. The rate constant for the disappearance was independent of pH within the range 4 to 9. Below pH 4 the disappearance was more rapid. These and other observations are consistent with a mechanism involving the radical equilibria: $RSSR^- + H^+ \rightleftharpoons [RSSR] \ldots HRS \rightarrow +RSH$. A comprehensive mechanism is presented, together with the absolute rate data for the various radical reactions involved. (auth) (UK)

2167 KINETICS OF OH RADICAL REACTIONS IN RADIOLYSIS, PHOTOLYSIS, AND THE FENTON SYSTEM. Kraljic, I. (CEN, Saclay, France. Faculte des Sciences, Orsay, France). pp 303-9 of Chemistry of Ionisation and Excitation. Johnson, G. R. A.; Scholes, G. (eds.). London, Taylor and Francis, 1967.

From Conference on Radiation Chemistry and Photochemistry, Newcastle upon Tyne, Eng., Sept. 21–23, 1966. See CONF-660955.

In the radiolysis of air-saturated aqueous solutions at pH 9, p-nitrosodimethylaniline (RNO) is a specific OH radical scavenger. Competition for OH radicals between RNO and other solutes in different aqueous systems was studied. Rate constants for the reaction of OH radicals with some inorganic and organic compounds, including biological macromolecules (DNA, etc.), are presented. In photolytic studies (using the system H_2O_2 + RNO, air-saturated aqueous solutions) results for relative rate constants were in good agreement with the radiolytic values, indicating that the OH radical is the reactive species in both systems. Some doubts still exist about the nature of the reactive intermediate formed in the Fenton system. Competition studies carried out in the system Fe^{2} + H_2O_2 + RNO (air-saturated acid solutions) strongly indicate that the reactive species is an OH radical. Some rate constants obtained in this system are presented. The pH dependence of the rate constants for the reactions of OH with Cl^- and Br^- was studied; the results were comparable to those obtained by other authors in electron pulse experiments. The kinetic results obtained with RNO indicate that the OH radical is the strongly oxidizing intermediate formed in the radiolysis of aqueous solutions, in the photolysis of dilute H_2O_2, and in the Fenton system. (auth) (UK)

2168 CONTROLLABLE DEGRADATION OF α-OLEFIN POLYMERS USING IRRADIATION. Potts, James E. (to Union Carbide Corp.). U. S. Patent 3,349,018 Filed Oct. 28, 1963.

A method for uniformly and controllably degrading α-olefin polymers containing at least about 50% by weight α-olefin, the balance being an olefinic hydrocarbon copolymerizable therewith and having the repeating unit $(-CH(R)-CH_2-)$ wherein R is an alkyl group containing from about 1 to 16 carbon atoms is described. The α-olefin polymer was subjected to ionizing radiation having an energy in the range from about 50 keV to about 20 meV to a total dose between about 0.01 to about 3 MR, whereby the molecular weight of the polymer decreased. (U.S. Pat. Gazette)

Radiochemistry

Refer also to abstracts 2436, 2475, and 2784.

2169 QUANTITATIVE STUDIES ON THE HYDROXYLATION-INDUCED MIGRATION OF DEUTERIUM AND TRITIUM DURING PHENYLALANINE HYDROXYLATION. Guroff, Gordon; Daly, John (National Inst. of Health, Bethesda, Md.). Arch. Biochem. Biophys., 122: 212-17(Oct. 1967).

Quantitative studies on the hydroxylation of deuterated and tritiated phenylalanines by phenylalanine hydroxylase have been carried out. Over 90% of the 4-tritium of phenylalanine migrates upon hydroxylation and is retained in the 3-position of the product, tyrosine. No isotope effect is involved in the hydroxylation of 4-deutero- or 4-tritiophenylalanine, or of 3,5-dideuterophenylalanine. The release of tritium from the 3-position during 4-hydroxylation was studied. The small amount of release observed provides evidence as to the mechanism of the hydroxylation-induced migration. (auth)

2170 CHEMISTRY OF POLONIUM. Hsia, Sheng-lan. Hua Hsueh Tung Pao, No. 1, 38-41(Jan. 1964).

Polonium was the first element discovered through its properties of radioactivity. It is a product resulting from the disintegration of radium. All the 27 isotopes of polonium discovered are radioactive. Most of them emit α particles and have a short half-life. The physical and chemical properties of polonium and its compounds and the preparation and the properties of the elemental polonium are discussed. Also, the metallic compounds of polonium, polonium oxides, sulfides, hydroxides, inorganic and organic acids of polonium, preparation and separation of polonium, and the uses of polonium are described. (JPRS)

Separation Processes

Refer also to abstracts 2102, 2335, 2362, 2469, 3697, 3931, and 3939.

2171 (CEA-R-3245) SEPARATION ANALYTIQUE DE TRACES DE NEPTUNIUM DE SOLUTIONS TRES CONCENTREES EN URANIUM PAR CHROMATOGRAPHIE EN PHASE INVERSEE DANS LE SYSTEME TLA–HNO_3. (Analytical Separation of Traces of Neptunium from Highly Concentrated Uranium Solutions Using Reversed Phase Chromatography in the TLA–HNO_3 System). Gourisse, Daniel; Chesne, Andre (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). May 1967. 27p. (In French). Dep.

The neptunium(IV) partition between nitric acid–uranyl nitrate solutions and Kel F powder coated with a trilaurylammonium–nitrate solution has been studied in order to determine the optimum operating conditions for separating neptunium from uranium. Reversed phase partition chromatography was performed by passing a 2 N HNO_3 0.1 M Fe^+ solution containing neptunium, plutonium, and up to 100 g/l of uranium through a column of TLAHNO_3–Kel F beads. After washing the column with a N HNO_3 solution containing a reducing agent, the neptunium is eluted by a sulfuric acid–nitric acid mixture. This method proved to be very selective for tetravalent neptunium; therefore leading to a good separation from fission products, plutonium, and uranium. It has been applied to solutions in which the molar ratio U/Np was greater than 10^{10}. The only limitation depends upon the sensitivity of the neptunium determination in dilute solutions. (auth)

2172 (ISO-SA-46) THE REDOX PLANT AND ITS APPLICATION TO AMERICIUM–CURIUM RECOVERY FROM SHIPPINGPORT FUELS. Rathvon, H. C. (Atlantic Richfield Hanford Co., Richland, Wash.). Oct. 12, 1967. Contract AT(45-1)-1851. 30p. (CONF-671025-1). Dep. CFSTI.

From Tri-City Realty Board Conference, Kennewick, Wash.

A scheme to recover curium and americium, coupled to the scheduled Shippingport fuel reprocessing program at the Redox plant, is described. (M.C.G.)

2173 (K-L-1780(Pt.21)) ORGDP FUEL REPROCESSING STUDIES. Progress Report for Period Ending June 30, 1967. Pashley, J. H. (Oak Ridge Gaseous Diffusion Plant, Tenn.). Sept. 22, 1967. Contract W-7405-eng-26. 27p. Dep. CFSTI.

Decladding runs were continued in the semiworks reactor. Oxidation tests were conducted with EGCR pellets to test possible flow sheet variations and to determine how sensitive this mate-

rial is to control of operating conditions. Filters were performance tested in volatility process corrosive atmospheres. Work was continued on the systems analysis program and the conceptual plant studies. Calculations were made to determine the maximum radioactive heat load on the main fluidized-bed reactor when fission products have built up in the recycled alumina.

2174 (KFK-573) UNTERSUCHUNGEN ZUR AUFLOESUNG VON UO_2-Mo-KERNBRENNSTOFFEN IN SALPETERSAEURE. (Investigations on Dissolution of UO_2-Mo Fuel Cores in Nitric Acid). Baehr, W. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Heisse Chemie). Feb. 1967. 52p. (In German). Dep.

The dissolution behavior of UO_2-Mo fuels with 10 to 20% Mo content was investigated in nitric acid alone and in nitric acid-iron nitrate solution. Dissolution rates, dissolution velocities, and total solution time were determined as a function of the nitric acid concentration. The possibility of using ultrasonics in the dissolution of UO_2-Mo fuels in nitric acid was tested. With respect to the further processing of such nuclear fuel materials, the U and acid concentrations reached in the dissolution process are of great interest. For this reason optimum conditions for the dissolution step were established and the resulting solutions were analyzed. The adsorption behavior of some important fission products on Mo oxide precipitates and their distribution in the various process solutions were determined. (tr-auth)

2175 (NP-17077) SEPARATION URANIUM THORIUM SUR RESINES ANIONIQUES. (Uranium-Thorium Separation on Anion Resins). Pelletier, Anne-Marie (Grenoble Univ. (France). Faculte des Sciences). [1965]. 24p. (In French). Dep. Thesis.

In the preparation of thin sources of ^{231}Th for the β spectrometric study of conversion electrons connected with transitions between excited levels of ^{231}Pa, the separation of U and Th on anion resins was studied. General characteristics of anion resins are described and previous works on U-Th separation on anion resins is reviewed. Preliminary studies were made using natural U. It was determined that in 9 N hydrochloric acid medium U and Th can be separated on an anion resin. The same technique was used on 90% enriched U. It was possible in this way to prepare thin sources of ^{231}Th without manipulation of the U. Extraction of Pa from the eluant was also studied. The results show that Pa is not eluted from the anion column by 9 N HCl. (J.S.R.)

2176 (ORNL-IIC-10(Vol.1), pp 298-314) SEPARATION OF CARRIER-FREE ^{131}Cs FROM NEUTRON-IRRADIATED BARIUM USING AMP AND AMP-ASBESTOS. Buchanan, J. D.; Sorensen, B. H.; Armstrong, J. C. (Hazleton-Nuclear Science Corp., Palo Alto, Calif.).

An ion-exchange process was used to recover 50- to 150-mCi quantities of ^{131}Cs from approximately 10 grams of neutron-irradiated $BaCO_3$. A dilute acid solution of the target material was passed through a small column containing a mixture of ammonium molybdophosphate (AMP) and acid-washed asbestos. Cesium was adsorbed on the AMP. Barium and other impurity elements passed through the column. After rinsing the column with dilute acid, then water, the AMP was dissolved and separated from the asbestos by passing a LiOH solution through the column. It was found that Cs remained on the asbestos in this step. After rinsing LiOH from the asbestos with water, ^{131}Cs was eluted with dilute acid. Yields were 95% or better. Radiochemical purity was greater than 99.9%. A batch extraction process was used for the initial separation of curie quantities of ^{131}Cs from 400 to 600 grams of irradiated barium carbonate. An acid solution of the target was contacted twice with AMP, and the AMP separated by filtration. The AMP was dissolved in NaOH and the NaOH solution was evaporated to reduce the volume and to remove NH_3. This solution was acidified and the processing was completed on a small AMP-asbestos column. With this combined batch extraction and column method, it was possible to concentrate carrier-free ^{131}Cs to greater than 200 mCi/ml. (auth)

2177 (ORO-2576-24) EXTRACTION OF INORGANIC COMPLEXES FROM AQUEOUS MEDIA BY CERTAIN ALKYL AMMONIUM COMPOUNDS. Final Report, June 1, 1959-August 31, 1967. (Louisiana State Univ., New Orleans. Dept. of Chemistry). Contract AT(40-1)-2576. 14p. Dep. CFSTI.

The use of long-chain alkyl ammonium extractants to prepare a wide variety of complex metal anions in nonaqueous solvents that cannot exist in aqueous solutions without the aid of large amounts of excess ligand is discussed. Lists of publications and papers presented at meetings, along with theses completed are given. (P.C.H.)

2178 (UJV-1899) OBZOR ISSLEDOVATEL'SKIKH RABOT V OTRASLI OBRABOTKI RADIOAKTIVNYKH OTKHODOV. (A Review of Experimental Works on the Treatment of Radioactive Waste). Berak, L.; (and others) (Ceskoslovenska Akademie Ved, Rez. Ustav Jaderneho Vyzkumu). Aug. 1967. 10p. (In Russian). Dep.

Experimental studies in the USSR on the treatment of radioactive wastes are briefly reviewed. The sorbents selected are described and the investigations and measurements of radiocolloids discussed. An installation for the processing of radioactive wastes from nuclear power stations is described. Disposal of radioactive sludges and residues is reviewed. The processing and storage of high-activity wastes is also considered. Studies on the mobility of radioactivity in soils are reported. (tr-auth)

2179 MECHANISM OF EXTRACTION OF HEXAVALENT URANIUM WITH BIS(2-ETHYLHEXYL)PHOSPHORIC ACID FROM NITRIC ACID SOLUTIONS. Nemodruk, A. A.; Glukhova, L. P. Radiokhimiya, 9: 304-9(1967). (In Russian).

The extraction of U(VI) with bis(2-ethylhexyl)orthophosphoric acid from HNO_3 solutions was studied. The distribution coefficients of U(VI) and Th(IV) were measured as a function of the HNO_3 concentration in the initial aqueous phase. On the basis of the results obtained and data reported in the literature, it is shown that in solutions with HNO_3 concentrations greater than 5 M, the extraction of hexavalent uranium with dialkylphosphoric acids is not governed by a solvation mechanism, but by an ion-exchange mechanism in which the hexavalent uranium apparently participates in the form of the quadruply charged UO_2^{++} ion. It was concluded that the extraction mechanism of U(VI) from solutions with high HNO_3 concentrations is the same as the extraction mechanism of such quadruply charged ions as Th^{4+}, U^{4+}, and Pu^{4+}. (ATD)

2180 APPLICATION OF ANION EXCHANGE RESINS FOR SEPARATION OF ELEMENTS. Ryabinin, A. I.; Artyukhin, P. I.; Bogatyrev, V. L. Radiokhimiya, 9: 335-40(1967). (In Russian).

Studies were made of separation of Cs, Ca, and Y isotopes under dynamic conditions using a strong base hydroxyl, oxalate, and carbonate anion exchange resin as precipitator and filter of the low-solubility compound. Two analytical schemes were developed for separation of ^{137}Cs, ^{45}Ca, and ^{91}Y produced radiochemically pure products. (R.V.J.)

2181 EXTRACTION OF ^{233}Pa FROM HYDROCHLORIC ACID SOLUTION BY ALCOHOL. Bulanova, I. D.; Vorob'ev, A. M. Radiokhimiya, 9: 381-4(1967). (In Russian).

The data obtained confirm the efficiency of the higher alcohols as solvents for the quantitative extraction of ^{233}Pa from hydrochloric acid solutions. The most useful were alcohols with dielectric constant of 9 to 14. The presence of isomers in the alcohol molecule and the substitution of the alkyl radical on the phenyl does not influence the extraction of Pa much from 6 to 8 N HCl. Complex compounds of Pa were solvated in the organic phase with four molecules of alcohol. (tr-auth)

2182 THE INFLUENCE OF ENTHALPY AND ENTROPY ON THE SEPARATION FACTOR OF THE LANTHANIDES IN THE HEHϕP-HNO_3 SYSTEM. Fidelis, I.; Siekierski, S. (Inst. of Nuclear Research, Warsaw). J. Inorg. Nucl. Chem., 29: 2629-35(Oct. 1967).

The enthalpy of the partition of the lanthanides between n-heptane-2-ethylhexyl phenylphosphonic acid and aqueous nitric acid solutions was determined by the temperature coefficient method. Variation of the entropy and free energy changes with atomic number relative to those for lanthanum were calculated. It has been established that the regularities observed previously in the separation factor within the lanthanide series are due to entropy or enthalpy effect, depending on which of these two factors is responsible for the increasing stability of the complex. Values of the enthalpy changes are negative for all lanthanides and large compared to those found in the case of EDTA-like ligands. (auth) (UK)

2183 EFFECT OF THE TEMPERATURE ON THE SEPARATION OF LANTHANIDES USING 2-ETHYLHEXYLPHENYL PHOSPHONIC ACID. Fidelis, Irena (Inst. of Nuclear Research, Warsaw). Nukleonika, 12: 471-85(1967). (In Polish).

Extraction coefficients or lanthanides in the 2-ethylhexyl ester of phenylphosphonic acid-HNO_3 system were measured over a temperature range from 15 to 50°C. The influence of temperature on the separation factors of the lanthanides, depending on the atomic number, was investigated. The accuracy of measurements was estimated by statistical methods. (auth)

2184 SEPARATION OF ALKALINE EARTH ELEMENTS BY CATION-EXCHANGE CHROMATOGRAPHY IN AMMONIUM MALONATE MEDIA. Strelow, F. W. E. (South African Council for Scientific and Industrial Research, Pretoria); Van Zyl, C. R.; Nolte, C. R. Anal. Chim. Acta, 40: 145-53(1968).

Be(II), Mg(II), Ca(II), Sr(II), and Ba(II) can be separated by elution from a cation exchange column in the ammonium form with increasing concentrations of ammonium malonate. A typical elution sequence for a 60-ml column (volume in H^+-form) of AG50-X8 resin is: 200 ml of 0.20 N ammonium malonate plus 0.10 N malonic acid for Be(II); 300 ml of 0.50 N, 450 ml of 0.70 N, 350 ml of 1.10 N ammonium malonate for Mg(II), Ca(II) and Sr(II), respectively, and 200 ml of 3.0 N nitric acid for Ba(II). Separations are sharp and quantitative for element pairs in weight ratios from 1:1000 to 1000:1. Distribution coefficients, elution curves, and quantitative separations are presented. (auth)

2185 EXTRACTION OF TETRAVALENT METALS WITH DI-(2-ETHYLHEXYL) PHOSPHORIC ACID. III. CERIUM. Tedesco, P. H.; de Rumi, V. B.; Quintana, J. A. Gonzalez (Univ. of La Plata, Argentina). J. Inorg. Nucl. Chem., 29: 2813-17(Nov. 1967).

The extraction of cerium(IV) from sulphuric solutions by di(2-ethylhexyl)phosphoric acid (DEHPA) dissolved in kerosene was studied. The effect of sulphate and of DEHPA concentration and of the pH on the extraction was determined. In order to interpret experimental data some equations are proposed. (auth) (UK)

2186 APPLICATION OF CLATHRATE CHROMATOGRAPHY TO THE SEPARATION OF ^{82}Br LABELLED BROMOBENZENES. Siekierski, Slawomir; Narbutt, Jerzy (Inst. of Nuclear Research, Warsaw). Nukleonika, 12: 487-92(1967).

Chemical forms of ^{82}Br, obtained in the process of neutron irradiation of bromoderivatives of benzene, were separated using a clathrate chromatography column. Very good separation of bromobenzene and of o-, m-, and p-dibromobenzenes was obtained. The dependence of the distribution ratios on the concentration of γ-picoline in the eluant was studied. It was found that the $Ni(\gamma\text{-picoline})_4(NCS)_2$ to C_6H_5Br mole ratio is in the clathrate 1:1. (auth)

2187 ELECTROCHEMICAL PROCESSES FOR THE ENRICHMENT OF ISOTOPES. Freyer, H. D.; Wagener, K. (Hahn-Meitner-Institut fuer Kernforschung, Berlin). Angew. Chem. Int. Ed. Engl., 6: 757-66(Sept. 1967).

The principles of electrochemical methods of isotope separation and the results obtained are described. The migration of ions in salt melts and solutions, complex formation in the homogeneous phase, electrolysis, ion-exchange equilibria, and exchange electrolysis are discussed in detail. (auth)

2188 SEPARATION OF Sm, Pm, AND Nd BY ION EXCHANGE WITH MIXED SOLVENTS. Ross, R.; Roemer, J. (Zentralinstitut fuer Kernforschung, Dresden). Isotopenpraxis, 3: 197-8(May 1967). (In German).

The separation of Sm, Pm, and Nd by anion exchange using mixtures of methanol and nitric acid as eluant was investigated. The content of methanol was varied from 50 to 75%, and the acid was 14.8N. Typical separation curves are shown and the separation factors were determined. These results show that with increasing methanol content the separation factors and the volume distribution coefficient increase. Very good separations can be obtained with low amounts of Nd and Sm. A methanol content of 65% is the optimum. The separation of Pm from Nd can be completed in an hour with good quality. The advantages of these eluants are discussed. (J.S.R.)

2189 PROCESS FOR SEPARATING BERYLLIUM VALUES FROM AQUEOUS SOLUTIONS. Crouse, David J. Jr.; Seeley, F. G. (to U. S. Atomic Energy Commission). U. S. Patent 3,359,064. Dec. 19, 1967.

A method of removing beryllium values from an aqueous acidic solution containing sulfate values is described. The aqueous solution was ap organic solution of a primary amine having two alkyl radicals on the primary carbon atom thereby extracting beryllium values into the organic solution. (AEC)

EARTH SCIENCES

Geology and Hydrology

Refer also to abstracts 2178, 2231, 2327–2329, 2332–2335, 2348, 2440, 2726, 3158, and 3968.

2190 (BNWL-SA-1457) THERMAL MODIFICATION OF RIVER WATER QUALITY. Jaske, R. T. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Oct. 18, 1967. Contract AT(45-1)-1830. 17p. (CONF-671033-1). Dep. CFSTI.

From 6th Biennial Hydraulics Conference, Pullman, Wash.

Thermal modification of the Columbia River as a result of the construction of storage reservoirs and increased water usage for cooling was analyzed. It was found that there was little or no effect on water temperature. The erection of hydraulic power dams and reservoirs has had only a nominal effect on the annual mean temperature of about 1°C over a period of 30 yr. The dams have altered the timing of the annual temperature change to a limited extent. The erection of Canadian dams can be expected to effect the annual temperature of the entire river. It appears that delays of 20 to 40 days will result and there should be a reduction of critical summer and fall temperatures resulting from the exposure of water to increasingly out of phase air temperature conditions. (F.S.)

2191 (FTB-5(Bibl.)) EASTERN TRANSLATIONS OF RADIOACTIVE GEOPHYSICS PROSPECTING LITERATURE. A Literature Survey. Nystrom, Anders (Aktiebolaget Atomenergie, Studsvik (Sweden)). Nov. 1967. 17p. Dep.

A set of 160 references was compiled covering translations or titles recommended for translation from 1965 through 1967 in the Transatom Bulletin and the Eastatom Supplement. Only eastern non-English original sources were considered. Translations are available for 99 of the compiled references and another 55 suggested for translation by Eastatom may be available from the address given in the introduction to the survey. The basic subjects covered are logging sources, instrumentation, data, and methods. Indexes are supplied for cover-to-cover journals; reported translations; titles recommended for translation; authors; and the title subject display subdivided in; Atomic and Rare Elements; Minerals and Compounds; Elementary Particle Fundamentals; Environmental Mapping and Data; Instruments and Equipments; and Methods, Theory, and General Aspects. (tr-auth)

2192 (IDO-22049) HYDROLOGY OF THE NATIONAL REACTOR TESTING STATION, IDAHO, 1966. Barraclough, J. T.; Teasdale, W. E.; Robertson, J. B.; Jensen, R. G. (Geological Survey, Idaho Falls, Idaho). Oct. 1967. 95p. Dep. CFSTI.

The hydrologic effects of disposal of radioactive waste to the ground at the National Reactor Testing Station was studied. Collection and analyses of ground- and surface-water samples for radiometric and chemical changes were made. Results were evaluated and mapped. Ground-water levels were also mapped over the station. The net ground-water consumption after pumpage and waste injection was determined. Two billion gallons of water were pumped during 1966 of which 40 percent was metered and returned to the Snake Plain aquifer. A record runoff of the Big Lost River during 1965 and 1966 induced a large amount of recharge to the Snake Plain aquifer. The recharge caused water levels to rise as much as six feet, but apparently did not have a great effect on the concentrations of waste products in the ground water. Pressure transmission, or mass transfer effects from the recharge, were observed as far as 50 miles southwest of the river. Tritium is the primary radioactive waste product discharged to the subsurface. Several aspects of tritium disposal were studied at the TRA (Test Reactor Area) and the ICPP (Idaho Chemical Processing Plant) areas. The distribution of waste tritium in the Snake Plain aquifer was mapped, and background levels were determined to range from 0.05 to 0.1 pCi/ml. Waste tritium in water from the Snake Plain aquifer was detected 4½ miles south of the ICPP. An estimated mass balance of total tritium remaining in the Snake Plain aquifer is presented for the TRA and ICPP areas. About 21,500 Ci (curies) of tritium at the ICPP and about 3,700 Ci at the TRA were disposed from 1952 through 1966. About 14,000 Ci and 2,700 Ci of tritium, respectively, should remain after radioactive decay. Similar amounts are indicated to be present in the ground water. Waste tritium has been used as a tracer in studies of the complex flow characteristics of the aquifer in the ICPP area. Dissolved Cr was used to trace TRA pond waste water in perched ground-water bodies and downgradient 2½ miles in the Snake Plain aquifer. Concentrations of hexavalent Cr ranged as high as 1.7 ppM in the perched water and 0.4 ppM in the water from the Snake Plain aquifer. Chromium serves as a good tracer of TRA wastes because it does not occur in nearby ICPP wastes, is not usually present in natural waters, and can be determined in very low concentrations. Natural fluoride in the water of the Snake Plain aquifer was used to trace the ground-water flow downgradient from the northeast end of the Snake River Plain. The fluoride, which is dissolved from certain rocks, indicates recharge areas and flow paths in the aquifer. A project to test the feasibility of disposing radioactive gases into the ground is presently underway. A seismic survey was used to map surface sediment thickness, and two test wells were cored to evaluate potential injection-well sites. A "breathing" well was instrumented to study flow rates, temperature, humidity, and other aspects of vertical flow of air in the well. Results of the continuing study are presented. Studies made on several wells which had vertically flowing borehole water indicated that the physical and chemical properties of the water are influenced by the flow. One well with downward flow had a head difference of 0.01 to 0.07 foot between two permeable zones throughout the year. (auth)

2193 (JUL-485-ST) UMWELTRADIOAKTIVITAET DER KERNFORSCHUNGSANLAGE JUELICH. JAHRESBERICHT 1966. (Environmental Radioactivity of the Juelich Nuclear Research Center. Annual Report, 1966). Vogt, K. J.; Jacobs, H.; Polster, G. (Kernforschungsanlage, Juelich (West Germany). Zentralabteilung Strahlenschutz). May 1967. 78p. (In German). Dep.

Results from radioactivity monitoring of atmosphere, water, soil, and milk at Juelich in 1966 are presented in tabular and graphic form. (J.S.R.)

2194 (RF/PROT-(67)14) A CONTRIBUTION TO THE STUDY OF THE SITE OF THE CASACCIA NUCLEAR RESEARCH CENTER. Cs^+ ION SORPTION CHARACTERISTICS OF CERTAIN REPRESENTATIVE SAMPLES OF TUFFS AND THEIR COMPONENTS. Progress Report No. 2. Boenzi, D.; Lenzi G. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). June 14, 1967. 19p. Dep.

The cesium sorption characteristics of tuffs in the vicinity of the Casaccia Nuclear Research Center, Italy, were determined. It is concluded that the chabazites and black pumices abundant in the area have a high selectivity for Cs^+ ions and constitute an important barrier against the contamination of aquifers. (L.C.L.)

2195 PROSPECTING OF UNDERGROUND WATER BY NATURAL RADIOACTIVITY. Ochiai, Toshiro. Genshiryoku Kogyo, 13: 43-50(July 1967). (In Japanese).

Prospecting for underground water by natural radioactivity is discussed. The technique including the analysis of the measurements and the application of the technique for the prospecting of coastal underground water is described. The reclaimed land in Hachirogata Lake, facing the Japan Sea, was surveyed for natural radioactivity, by means of radioactivity detectors mounted in an automobile. The principle employed was the approximately linear relation between the surface radioactivity detected and the (water) permeability, which give an indication of the degree of abundance of underground water. In the coastal area, it was confirmed that where the natural radioactivity was highest, the permeability (its coefficient) and the amount of water (obtained by digging a well) were the largest. (NSA of Japan)

2196 RETENTION OF ^{131}I USED AS TRACER IN WATER-MOVEMENT STUDIES. Hamid, A.; Warkentin, B. P. (McGill Univ., Montreal). Soil Sci., 104: 279-82(Oct. (1967).

Iodine-131 retention in marine-deposited clay soils was evaluated. Adsorption was measured with different competing anions at different salt concentrations and at varying pH values. The ^{131}I was assayed for γ radiation with a spectrometer using a solid NaI crystal scintillator. Keeping the pH value above 7 or the addition of stable iodide salt prevents the adsorption of ^{131}I on the clay particles. The ^{131}I can be used as a tracer in acid soils only in the presence of stable I^- carrier. (F.S.)

2197 NATURAL RADIATION ENVIRONMENT. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964. 1080p. $15.00.

Separate abstracts were prepared for each of the sixty-one papers presented. (B.G.D.)

For abstracts of individual papers see: 2198–2224, 2231–2245, 2288, 2375–2383, 2412–2415, 2425, 2437, 2517, 2555, and 2858.

2198 THE COLORADO FRONT RANGE, COLORADO, U.S.A., AS A URANIUM AND THORIUM PROVINCE. Phair, George; Gottfried, David (Geological Survey, Washington, D.C.). pp 7-

38 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Geographic patterns of U and Th distribution in this area are presented as a possible starting point for detailed investigations by those interested in minable Th. The data were collected by reconnoitering the major rock types that form the building blocks of the mountains in this 7000-sq-mi area. The information presented is primarily concerned with the moderate but widespread regional anomalies that set the Front Range apart as a unit. Information is included on average U and Th contents of the continental crust, laramide intrusives. Pikes peak type rocks, silver plume type rocks, boulder creek type rocks, and older rocks. Data on U and Th contents are tabulated. (J.R.D.)

2199 THORIUM, URANIUM, AND POTASSIUM IN THE CONWAY GRANITE, NEW HAMPHIRE, U.S.A. Richardson, K. A. (Rice Univ., Houston, Tex.). pp 39-50 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

An area of high radioactivity of natural terrestrial origin is outlined and the occurrence of radioelements in the rocks of the area is indicated. Information is included on the geologic setting Th, U, and K in the Conway granite, and α-emitter sites. (J.R.D.)

2200 STATISTICAL TESTS OF THE HOMOGENEITY OF THE RADIOACTIVE COMPONENTS OF GRANITIC ROCKS. Rogers, J. J. W. (Rice Univ., Houston, Tex.). pp 51-62 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

The distribution of Th and U in U.S. granites is discussed. Included is a mathematical definition of homogeneity and discussions of geologic aspects of homogeneity. Discussions of New England granites are included in which these granites are compared with those from other locations in the U.S. (J.R.D.)

2201 URANIUM, THORIUM, AND POTASSIUM CONTENTS IN BASIC ROCKS AND THEIR BEARING ON THE NATURE OF THE UPPER MANTLE. Heier, K. S. (Australian National Univ., Canberra); Carter, James L. pp 63-85 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Earth crust components such as basalts, amphibolites, basic instrusives, and eclogites are discussed along with upper mantle characteristics. It is noted that Th and U data alone are not sufficient to define the chemical conditions in the upper mantle. Data tabulations on Th and U contents in basic and ultrabasic rocks are included along with histograms of Th and U in basic volcanic rocks. (J.R.D.)

2202 THE THORIUM, URANIUM, AND POTASSIUM CONTENTS OF ATLANTIC AND GULF COAST BEACH SANDS. Mahdavi, Azizeh (Rice Univ., Houston, Tex.). pp 87-114 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Descriptions and results of the measurements are presented. It was found that Th, U, and K can be determined in the field by α spectrometry. Th above 1 ppM and U above 0.3 ppM are contained in dense beach sand minerals such as monazite, zircon, and xenotine. Most beaches have a Th/U ratio of 2.5. The concentrations of Th, U, and K can probably be used to tracers and indicators of geologic situations. (J.R.D.)

2203 AUTORADIOGRAPHIC INVESTIGATIONS OF NATURALLY OCCURRING MATERIALS. Ragland, Paul G. (Univ. of North Carolina, Chapel Hill). pp 129-51 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

An analysis of information obtained by autoradiography of rocks is presented. Suggestions concerning applications of radiographic methods are included. Discusssions of distribution of α emitters in constituent minerals are also included along with data on α activity in various rocks. (J.R.D.)

2204 THE DISTRIBUTION OF THE HEAVY RADIOELEMENTS IN THE ROCKS AND WATERS OF FLORIDA. Osmond, J. K. (Florida State Univ., Tallahassee). pp 153-9 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Early efforts in a program to investigate the distribution of heavy elements in sediments and waters of Florida are described. Progress in the program have largely been in the area of low level radioisotopic measuring. Data from preliminary sample analyses are included. (J.R.D.)

2205 RADON MIGRATION IN THE GROUND: A REVIEW. Tanner, Allan B. (Geological Survey, Washington, D. C.). pp 161-90 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

A review is presented in which factors that determine the distance that radon isotopes may migrate in the ground are discussed. The geophysical and geochemical implications of radon migration are also discussed. A bibliography of 162 references is included. (J.R.D.)

2206 CONTENT OF URANIUM, RADIUM, AND THORIUM IN RIVER WATERS IN JAPAN. Miyake, Yasuo (Meterological Research Inst., Tokyo); Sugimura, Yukio; Tsubota, Hiroyuki. pp 219-25 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

The rivers were sampled during the period from late July to early August 1961. Data from water analyses are included. Differences between the relative abundances of U, Ra, and Th in river water and those found earlier in land minerals are interpreted as being the results of fractionation during weathering processes. (J.R.D.)

2207 ^{210}Pb (RaD) AND ^{210}Po (RaF) IN POTABLE WATERS IN ILLINOIS. Holtzman, Richard B. (Argonne National Lab., Ill.). pp 227-37 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

The study was conducted to investigate the nature of ^{210}Pb and ^{210}Po and to estimate the contribution of potable water to the body content of these isotopes in humans. Sampling methods and results are discussed. It is concluded that potable water does not constitute an important source of ^{210}Pb in the human skeleton. (J.R.D.)

2208 A STUDY OF ENVIRONMENTAL EXPOSURE TO RADIUM IN DRINKING WATER. Samuels, Larry D. (Public Health Service, Iowa City, Iowa). pp 239-51 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Results of investigations of Ra content in midwest U. S. drinking water are presented. Information is included on geology and geography of the study area, numbers of people exposed to high-Ra water, uptake variables, and body burdens. (J.R.D.)

2209 PHYSICAL AND CHEMICAL CONTROLS OF DISTRIBUTION OF ^{226}Ra AND ^{222}Rn IN GROUND WATER NEAR GREAT SALT LAKE, UTAH. Tanner, Allan B. (Geological Survey, Washington, D. C.). pp 253-76 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Chemical data are provided to supplement radioactivity data to promote understanding of ^{226}Ra and ^{222}Rn behavior in specified environments. Mechanisms of ^{226}Ra and ^{222}Rn control in ground water are suggested. Data and discussions are presented to support conclusions that ^{222}Rn content in the water is mainly dependent on sediment-contained ^{226}Ra near wells. Much of the ^{226}Ra is derived locally from ^{230}Th, and additional ^{226}Ra may flow from upstream sources. ^{222}Rn anomalies in ground water may be related to changes in chemical environment. (J.R.D.)

2210 A FAST AND ACCURATE SURVEY TECHNIQUE FOR BOTH ^{222}Rm AND ^{226}Ra. Lucas, Henry F. Jr. (Argonne National Lab., Ill.). pp 315-29 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Fast and reliable methods for water sampling and sample assay for ^{222}Rn and ^{226}Ra are described. (J.R.D.)

2211 ALPHA PARTICLE DETECTION TECHNIQUES APPLICABLE TO THE MEASUREMENT OF SAMPLES FROM THE NATURAL RADIATION ENVIRONMENT. Cherry, R. D. (Univ. of Cape Town). pp 407-24 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Detection techniques useful in measuring α activity in samples from the natural environment are reviewed. Discussions are included concerning total counting with no energy measurements and spectrographic techniques used when α particle energies are measured to identify specific nuclides. (J.R.D.)

2212 MEASUREMENT OF γ-EMITTING RADIONUCLIDES IN SOIL AND CALCULATION OF THE DOSE ARISING THEREFROM. Gustafson, Philip F.; Brar, Sarmukh S. (Argonne National Lab., Ill.). pp 499-512 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

A method using γ spectrometry of soil cores to determine natural and fission-product radioactivity present is described. Results of direct measurements are also discussed and compared with results

of calculations. The method appears to be adequate as a means of determining the contribution of natural and fission-product γ-type radioactivity to the total dose rate measured in situ. (J.R.D.)

2213 STUDIES IN TERRESTRIAL γ RADIATION. Wollenberg, Harold A.; Smith, Alan R. (Univ. of California, Berkeley). pp 513-66 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Theory and practical aspects of collecting and analyzing data on environmental γ radiation intensity and on the concentrations of γ emitters in rock formations are discussed. Quantitative assays for K, U, and Th were done by laboratory analysis. Valid U and Th assays require that the decay series have reached secular equilibrium. Errors introduced by lack of equilibrium have not been thoroughly studied. (J.R.D.)

2214 FIELD SPECTROMETRIC INVESTIGATIONS OF ENVIRONMENTAL RADIATION IN THE U.S.A. Lowder, Wayne M.; Condon, William J.; Beck, Harold L. (Atomic Energy Commission, New York). pp 597-616 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Equipment is described for use in estimating the additive effects of γ-emitting fallout on total environmental radiation dose rates measured with ionization chambers. Efforts to utilize γ spectrometers for separation of the radiation field into its various components are described. Information is included on calibration of spectrometers to account for natural emitters, fallout emitters, and the total dose. (J.R.D.)

2215 RADIOACTIVITY OF SOME ROCKS, SOILS, PLANTS, AND BONES. Marsden, Ernest (Dominion Physical Lab., N. Z.). pp 807-24 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Observations made primarily in the Pacific Island Niue are summarized. Discussions are included concerning phosphate rocks used in fertilizer, effects of soil and type on α activity in wheat, radioactivity of plankton and shell fish, and possible radiation effects on the human population of Niue. (J.R.D.)

2216 EXTERNAL RADIATION LEVELS IN HIGH-BACKGROUND REGIONS OF BRAZIL. Roser, F. X.; Cullen, T. L. (Catholic Univ., Rio de Janeiro). pp 825-36 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

The geology of high-background radiation regions in Brazil including the monazite sands along the Atlantic Coast and the zone of volcanic alkaline intrusives in the inland states of Minas Gerais and Goias is described. (J.R.D.)

2217 NATURALLY OCCURRING RADIONUCLIDES IN FOODS AND WATERS FROM THE BRAZILIAN AREAS OF HIGH RADIOACTIVITY. Eisenbud, M. (New York Univ., N. Y.); Petrow, H.; Drew, R. T.; Roser, F. X.; Kegel, G.; Cullen, T. L. pp 837-54 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Results of a pilot study to determine the extent to which the naturally occurring radionuclides are present in typical foods and waters in the Brazilian areas of abnormally high radioactivity, are summarized. Information is included concerning potential sources of radioisotopes; properties of the U and Th series; ^{228}Ra and ^{226}Ra in food, water, and human bones; and analytical methods. (J.R.D.)

2218 RADIOGEOLOGY OF SOME HIGH-BACKGROUND AREAS OF BRAZIL. Roser, F. X.; Kegel, G.; Cullen, T. L. (Catholic Univ., Rio de Janeiro). pp 855-72 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Investigations in the areas of radioactive ore deposits in the alkaline eruptive plugs of the Triassic-Jurassic along fault lines where intensive hydrothermal mineralization developed are described. Similiar investigations in the Quaternary alluvial and eluvial deposits that originated from progressive weathering of primary rocks and erosion of sedimentary peneplains by transportation and successive concentration of monazite sand along river banks and beaches are also described. (J.R.D.)

2219 ENVIRONMENTAL RADIATION SURVEILLANCE IN THE ANTARCTIC. Busdiecker, R. L.; Maxwell, B. W. (Public Health Service, Washington, D. C.). pp 873-83 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Surveillance of environmental radiation from Dec. 1960 to Jan. 1963 at Byrd and McMurdo Stations in the Antarctica is described. Routine sampling was confined to air, snow, and camp water. Air radioactivity values suggest seasonal variations in both natural and artificial activity. Wide differences between radioactivity values for snow and camp water at McMurdo was attributed to use of older (subsurface) snow for camp water and activity removal by water filtration. The differences of radioactivity levels in snow and camp water was less at Byrd than at McMurdo. (J.R.D.)

2220 ENVIRONMENTAL RADIATION SURVEY IN NORTHERN NEW ENGLAND. Lowder, Wayne M. (Atomic Energy Commission, New York); Segall, Ascher; Condon, William J. pp 907-17 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Results are presented from surveys of bedrock radioactivity in Maine, N. H., and Vt. Results of environmental radiation surveys at selected locations in New England are also included along with results of personnel monitoring in this area. Results of analyses of area residents' teeth for ^{226}Ra, ^{224}Ra, and ^{210}Po are also presented. (J.R.D.)

2221 BACKGROUND RADIOACTIVITY MONITORING OF A PILOT STUDY COMMUNITY IN WASHINGTON COUNTY, MARYLAND. Pinkerton, Cecil (Robert A. Taft Sanitary Engineering Center, Cincinnati); Chen, William Y.; Hutchins, R. G.; Schrohenloher, Ralph E. pp 919-56 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Radiation monitoring surveys were conducted throughout Washington County, Maryland, with emphasis on measurements in the Sharpsburg community. It was found that aeroradiometric measurements can be related to ground dose and tenor of radioactive minerals when the measurements are made over large uniform areas. Results are tabulated and discussions of procedures and conclusions are included. (J.R.D.)

2222 ENVIRONMENTAL NATURAL RADIOACTIVITY MEASUREMENTS AT TROMBAY ESTABLISHMENT. Kamath, P. R.; Khan, A. A.; Rao, S. R.; Pillai, T. N. V.; Borkar, M. L.; Ganapathy, S. (Atomic Energy Establishment, Trombay, India). pp 957-78 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Results of systematic environmental radioactivity studies by the Trombay Establishment are reported. Discussions are included concerning radiochemical methods employed in the studies, background radiation near nuclear facilities, waste release effects, and on radioactivity of biological materials, soil, vegetation, and water. (J.R.D.)

2223 DETERMINING THE CONTRIBUTION OF γ RAYS TO THE NATURAL ENVIRONMENTAL RADIATION AT GROUND LEVEL. Geyh, M.; Lorch, S. (Niedersaechsisches Landesamt fuer Bodenforschung, Hannover). pp 979-88 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Results of measurements are reported that were carried out over a period of several years concerning the contribution of γ radiation to the natural environment in west Germany. Portable scintillation counters were found useful in the measurements. Accuracies of 30% were estimated for open terrain measurements made without leaving the roads. It was found that relatively few measurement points were required to establish the radiation levels of an area. (J.R.D.)

2224 ENVIRONMENTAL RADIOACTIVITY SURVEYS IN SPAIN. Ramos, Eduardo; Celma, Margarita (Nuclear Energy Board, Madrid). pp 989-1007 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Results of radioactivity surveys in Spanish air, water, soils, vegetation, and milk are reported. The measurements cover the period June 1959 to Nov. 1962. (J.R.D.)

Meteorology

Refer also to abstracts 2214, 2220–2224, and 3987.

2225 (NYO-841-11) HARVARD AIR CLEANING LABORATORY ANNUAL PROGRESS REPORT, SEPTEMBER 1, 1966-AUGUST 31, 1967. First, M. W.; Viles, F. J. Jr.; Reist, P. C.; Smith, D. G.; Underhill, D. W.; Moeller, D. W. (Harvard Univ., Boston, Mass. Harvard Air Cleaning Lab.). Oct. 1967. 14p. Dep. CFSTI.

The work accomplished at the Harvard Air Cleaning Laboratory from September 1966 to September 1967 is reported. Included are lists of papers presented at technical meetings and consulting

services rendered, experimental work in air cleaning to remove iodine and oxides vented from the reactor of the N. S. Savannah and to remove sodium vented from fast reactors, studies of water removal from saturated atmospheres, ^{85}Kr sampling and removal, an investigation of the theory and feasibility of using porous underground strata as storage sites for waste ^{85}Kr gas, and materials research to develop a suitable "diffusion board" for application to problems of reactor containment. (L.C.L.)

2226 (NYO-3317-1) STUDY OF THE TROPOPAUSE BASED ON NUMERICAL INTEGRATION OF THE POTENTIAL VORTICITY EQUATION. Final Report Part 1. Danielsen, Edwin F.; Diercks, John W. (Pennsylvania State Univ., University Park). Feb. 1967. Contract AT(30-1)-3317. 43p. Dep. CFSTI.

Numerical integration of the potential vorticity equation was performed for a multilevel isentropic model. The primary purpose of the numerical experiment was to study the advection of the tropopause. Initial conditions favorable for tropopause folding by quasi-horizontal motions were specified. Successful integrations were obtained for twenty-three one hour time steps. At the end of this period tropopause folding was initiated west of the trough. The numerical model and the relevant equations are discussed. The initial and predicted positions of the tropopause are illustrated by vertical cross-sections which include also the distributions of potential temperature, potential vorticity, and the wind speed normal to the cross-sections. (auth)

2227 (RA-29) GROSS RADIOACTIVITY OF AIRBORNE DUST. RESULTS OF MEASUREMENTS DURING 1965. van Dongen, R.; Moonen, H. P. M.; Wolf, H. J. (Rijks Instituut voor de Volksgezondheid, Utrecht (Netherlands)). May 1967. 17p. Dep.

Gross long lived alpha, beta, and gamma activities of airborne dusts, collected at De Bilt/Bilthoven, The Netherlands, during 1965, are reported. The counting efficiencies of ^{140}Ba, ^{144}Ce, ^{137}Cs, ^{131}I, and ^{95}Zr were measured in the energy level from 80 keV to 2 MeV. Results are discussed. (F.S.)

2228 (SC-CR-67-2645) FURTHER DEVELOPMENT OF THE MODEL B COMPUTER CODE FOR ESTIMATING PARTICLE FALL AND DISPERSION IN THE ATMOSPHERE. Final Report. Hage, K. D. (Travelers Research Center, Inc., Hartford, Conn.). Aug. 1967. Contract 48-4932. 108p. Dep. CFSTI.

For Sandia Corp., Albuquerque, N. Mex.

A computer code developed previously as a tool for investigating possible hazards associated with aborted missions and orbital-decay reentries of space vehicles using nuclear fuels is modified and refined for increased accuracy and usefulness. Model calculations of the transport and dispersion of monodisperse particles suggest that reasonable estimates of concentrations and densities can be obtained from a Gaussian mass distribution function for particles of 20 microns dia and larger. The two-dimensional subdivision procedures contained in Model B appear to be superior to both one-dimensional and three-dimensional subdivision for calculating the dispersion of monodisperse particles. (auth)

2229 DENSITY OF FALLOUT PARTICLES FROM AIR-BURSTS. Benson, P. A.; Nathans, M. W.; Amos, A.; Leventhal, L. (Tracerlab, Richmond, Calif.). Contract AT(04-3)-453. Health Phys., 13: 1331-5(Dec. 1967).

The densities of seventy-three individual fallout particles from three events of the Dominic series were measured by means of a miniaturized terminal velocity method. The particles varied from 4 to 16 μ in diameter. The results were: event A: $\rho = 3.75 \pm 0.42$ g/cm^3; event B: $\rho = 3.60 \pm 0.22$ g/cm^3; event C: $\rho = 3.88 \pm 0.27$ g/m^3. These results are well below the theoretical densities for iron oxide-aluminum oxide mixtures, and are consistent with the noncrystalline nature of the particles and with the presence of microvesiculation. No correlation between the density and the diameter of the particles was found. (auth) (UK)

2230 NUCLEAR POWER AND ITS RELATION TO AIR POLLUTION. Grob, John J. Jr. (Consolidated Edison Co., New York). 17p. (CONF-670609-2). DTIE.

From 60th Annual Meeting of the Air Pollution Control Association, Cleveland.

The use of nuclear energy to produce electricity provides a means by which the electric industry's contribution to air pollution may be essentially eliminated. Nuclear plants can be designed to operate at power without the continuous emission of radioactive waste. The wastes which do arise coincident to the operation of nuclear plants can be stored, processed and released under controlled conditions with due consideration of meteorological conditions and their effects on the environment. It has been proved possible to design the waste control system of nuclear plants so that the emissions are well within the requirements of Federal regulations. These standards are set at levels which have been found to result in undetectable effects on the environment except right at the source of emission. Radioactive gaseous releases from ordinary operation of nuclear plants consist of isotopes of the noble gases which do not enter man's food chain or body tissues. Concentrations of radioactive isotopes due to normal background are substantially higher than concentrations which might be caused by release of wastes due to nuclear power plant operation. It may be reasonably stated that operation of nuclear power plants has not and will not change the ecology. (auth)

2231 MEASUREMENTS OF THE EFFECTS OF ATMOSPHERIC VARIABLES ON ^{222}Rn FLUX AND SOLID-GAS CONCENTRATIONS. Kraner, Hobart W.; Schroeder, Gerald L.; Evans, Robley D. (Massachusetts Inst. of Tech., Cambridge). Contract AT(30-1)-952. pp 191-215 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

The measurements were made at the Nevada Test Site. Atmospheric pressure changes were found to affect the ^{222}Rn concentration to depths greater than 8 ft in weathered tuff. The entire ^{222}Rn concentration gradient appears to be shifted by atmospheric pressure. Soil moisture is related to high ^{222}Rn concentrations. High wind speeds appear to decrease ^{222}Rn concentrations to depths of 44 in. in weathered tuff. (J.R.D.)

2232 TECHNIQUES EMPLOYED AT THE U.S. NAVAL RESEARCH LABORATORY FOR EVALUATING AIR-BORNE RADIOACTIVITY. Lockhart, L. B. Jr.; Patterson, R. L. Jr. (Naval Research Lab., Washington, D. C.). pp 279-89 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

The sampling procedures used involve both rain collection and air filtration. Because of convenience, reliability, and simplicity, air filtration is preferred to rain water collection sampling. Information and data are included on ^{210}Pb in rain, ^{210}Pb, ^{214}Pb, and ^{212}Pb in air, and retention of aerosols by filters. (J.R.D.)

2233 SOME PROPERTIES OF NATURAL RADIOACTIVITY IN THE ATMOSPHERE. Kawano, M. (Nagoya Univ., Japan); Nakatani, S. pp 291-314 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Results of measurements of atmospheric radioactive dust concentrations are reported. Measurements on dust collected by electrostatic precipitation are compared with simultaneous measurements using ionization chambers. Discussions are included concerning the collecting efficiency of electrostatic precipitators, counting efficiency of Geiger-Mueller tubes, and the effects of the presence of ^{220}Rn and its daughters on measurement results. It was found that the concentrations of dust collected by precipitation is not always proportional to that of radiactive substances measured by ionization chambers. Reasons for discrepancies are discussed. (J.R.D.)

2234 RADIOACTIVITY OF THE ^{222}Rn AND ^{220}Rn SERIES IN THE AIR AT GROUND LEVEL. Lockhart, Luther B. Jr. (Naval Research Lab., Washington, D. C.). pp 331-44 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Results of ground-level radioactivity measurements at western hemispheric stations both north and south of the equator are presented. Results of data analysis indicate that atmospheric radioactivity distribution is affected by time of day, season, weather, and past history of nuclear testing. Natural radioactivity variations appear to be usable in studies of movement and mixing of air masses. The simultaneous study of ^{222}Ra and ^{212}Pb may reveal long-term and short-term atmospheric processes. (J.R.D.)

2235 RADON-DAUGHTER IONS IN THE ATMOSPHERE. Wilkening, Marvin H. (New Mexico Inst. of Mining and Tech., Socorro). pp 359-68 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Investigation of measuring methods reveal that negative-wire apparatuses measure only the radon-daughter small ions of positive charge and high mobility that result during decay of ^{222}Rn and its short-lived daughters. An anomalous decrease in the daughter-ion activity may occur in the total absence of precipitation at a sampling station, provided that a storm center is sufficiently close to produce an electric field reversal. The daughter-ion correlates with the total small-ion content of the atmosphere is a useful tool in studying atmospheric electrical environment. (J.R.D.)

2236 MEASUREMENT OF NATURALLY OCCURRING RADIONUCLIDES IN AIR. Gold, S.; Barkhau, H. W.; Shleien, B.; Kahn, B. (Robert A. Taft Sanitary Engineering Center, Cincinnati). pp 369-82 of Natural Radiation Environment. Adams,

John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Results of measurements of naturally occurring radioactivity associated with air particulates in Cincinnati, Ohio, are presented. Seasonal variations are shown by minimum early-morning ^{222}Rn averages in March and maximum averages in September. Concentrations are affected by air stability and precipitation. ^{220}Ra concentrations are approximately 1% of ^{222}Rn values and are parallel to them. (J.R.D.)

2237 GEOGRAPHICAL DISTRIBUTION OF ^{210}Pb(RaD) IN THE GROUND-LEVEL AIR. Patterson, R. L. Jr.; Lockhart, L. B. Jr. (Naval Research Lab., Washington, D. C.). pp 383-92 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Concentrations of ^{210}Pb in air as function of time are correlated with ^{222}Rn concentrations observed concurrently at the same sites. It is concluded that short-term measurements of ^{210}Pb in air cannot be used to define its average activity concentration in an area. The $^{210}Pb/^{222}Rn$ ratio is generally unsatisfactory for determination of the residence time of ^{210}Pb in the atmosphere. (J.R.D.)

2238 LOW-LEVEL RADIOACTIVE CONTAMINATION. Weller, Richard I. (Franklin and Marshall Coll., Lancaster, Pa.). pp 567-75 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Discussions are presented of low-level radioactive contamination processes that have been made and that are in progress. The extent and mechanisms of radioactive contamination of materials and reagents is outlined along with its effects on research. Data on low-level contamination are included and low background detectors are discussed. (J.R.D.)

2239 THE AERIAL RADIOLOGICAL MEASURING SURVEYS (ARMS) PROGRAM. Guillou, Robert B. (Edgerton, Germeshausen and Grier, Inc., Santa Barbara, Calif.). pp 705-21 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

The Aerial Radiological Measuring Surveys (ARMS) program is described in sufficient detail to develop an understanding of what is measured and how, so that, as extensive ARMS data become available, workers in the natural radiation environment field can use them. Information is included on history of ARMS, instrumentation, data compilation methods, and uses of ARMS data. (J.R.D.)

2240 AERORADIOACTIVITY SURVEYS AND GEOLOGIC MAPPING. Pitkin, James A.; Neuschel, Sherman K.; Bates, Robert G. (Geological Survey, Washington, D. C.). pp 723-36 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

The ARMS I surveys are part of a nationwide program to obtain data on existing γ radioactivity for areas near nuclear facilities. The surveys are made with continuously recording scintillation detection equipment installed in an airplane. Design and operation of the equipment is described and comment is included on correlation of aeroradioactivity with areal geology. (J.R.D.)

2241 SOME AERIAL OBSERVATIONS ON THE TERRESTRIAL COMPONENT OF ENVIRONMENTAL γ RADIATION, Moxham, R. M. (Geological Survey, Washington, D. C.). pp 737-46 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Aeroradiometric surveys are described which can be used to find regional variations in radiation from which estimates may be made of terrestrial radioelement content and surface radiation intensities. Information is included on soil effects on radiation and on variations of radioelement content in relation to terrestrial emission. (J.R.D.)

2242 ATMOSPHERIC ATTENUATION OF γ RADIATION. Purvis, A. E. (Univ. of Dallas); Foote, R. S. pp 747-56 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

The effects of the atmosphere on the γ spectrum of the earth are examined. The change in the spectrum as a function of distance above the surface, and the change at fixed elevations due to variations in atmospheric mass density are emphasized. Experimental results indicate that accurate measurement of the γ spectrum of the earth must include the atmospheric concentration ^{214}Bi and that spectral data gathered below 500 ft reveal surface amounts of specific radionuclides. (J.R.D.)

2243 TIME VARIATION OF TERRESTRIAL γ RADIATION. Foote, Robert S. (Texas Instruments, Inc., Dallas). 757-66 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

A γ detection system using an $11\frac{1}{2}$-in.-dia by 4-in.-thick NaI crystal whose pulses are analyzed by a 200-channel pulse-height analyzer was used for measuring the amounts of each variable input from the environmental field γ radiation at 47 min intervals from 1962 to 1964. The results of handling large numbers have given confidence in the ability to understand the radioactive material involved in the γ field spectrum. The experiment also gave confidence to operation of remote monitoring stations. (J.R.D.)

2244 INVESTIGATIONS OF ENVIRONMENTAL RADIATION AND ITS VARIABILITY. Herbst, W. (Univ., Freiburg, i. B.). pp 781-96 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Measurements of the dose rate of external penetrating environmental radiation were made using ionization chambers to determine variations of terrestrial components. The effects of housing settlements, mining, road making, agriculture and forestry are examined. (J.R.D.)

2245 BACKGROUND RADIATION MEASUREMENTS IN THE ENVIRONS OF THE SAVANNAH RIVER PLANT, 1952–63. Hoy, J. E.; Landon, L. F. (E.I. du Pont de Nemours and Co., Aiken, S. C.). Contract AT(07-2)-1. pp 797-806 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

The results of the study and a description of the instruments and methods used are described. Rechargeable ionization chambers for environmental γ measurements were found adequate. Other techniques evaluated were not suited to replace the ionization chambers. The methods used provide reliable data for surveillance of the environs and an accurate evaluation of changes due to plant operation. (J.R.D.)

2246 INVESTIGATION OF RADIOACTIVE DUST IN THE UPPER ATMOSPHERIC LAYER. ANALYSIS OF FALL-OUT PARTICLES DUE TO A COMMUNIST CHINESE NUCLEAR TEST 1. Kenmochi, Kazuo; Urai, Tatsuo; (and others). Giho (Boeicho Gijutsu Kenkyu Honbu), 5: 1-15(Apr. 1966). (In Japanese).

The radioactivities in air and rain water are known to be largely influenced by large radioactive particles in the fallout from a nuclear explosion. Such particles collected 3 days after the first nuclear test by Communist China (Oct. 16, 1964) were investigated by activation analysis, micro x-ray diffraction, and elementary analysis using a microanalyzer. Micro x-ray diffraction showed that these particles were amorphous. The analysis of elements with a microanalyzer showed the main constituents of the large particles to be Al (~50%), Fe, Ca and Ti; the distribution of Fe was fairly localized in each particle. Of these elements, Al and Ca were considered to be from the soil, indicating the nuclear test was carried out on the earth surface. Fe and Ti were probably from the nuclear bomb itself. Uranium-235, -238, and Pu-239 were not detected. (NSA of Japan)

2247 OBSERVED RADIOACTIVITY IN AIRBORNE DUSTS COLLECTED BY THE DUST COLLECTOR (TABLE 4, APRIL–JUNE 1966). (Japan Meteorological Agency, Tokyo). Taiki Hoshano Kansoku Seiseki, No. 45, 45-63(Mar. 1967). (In Japanese).

The measured values of radioactivity in airborne dusts in cpm/10 m^3, for the respective days of the period from April to June 1966, are shown, which were obtained at Sapporo, Sendai, Tokyo, Osaka and Fukuoka. The values for the period ranged as follows: Sapporo 6 ~ 129, Sendai 12 ~ 108, Tokyo 13 ~ 105, Osaka 29 ~ 174, and Fukuoka 17 ~ 196 cpm/10 m^3. The radioactivities at 20 and 72 hours after the starting point, as well as the backgrounds, are also shown. (NSA of Japan)

2248 OBSERVED RADIOACTIVITY IN RAIN COLLECTED AT FIXED TIME DAILY (TABLE 3, APRIL–JUNE 1966). (Japan Meteorological Agency, Tokyo). Taiki Hoshano Kansoku Seiseki, No. 45, 10-44(Mar. 1967). (In Japanese).

The measured values of radioactivity in rain water in cpm/l, for the respective days of the period from April to June 1966, are shown, which were obtained at Wakkanai, Sapporo, Kushiro, Sendai, Akita, Tokyo, Wajima, Hachijo-jima, Osaka, Yonago, Murotomisaki, Fukuoka, and Kagoshima. The maximum values at each location are respectively 465, 229, 41, 1509, 2600, 660, 194, 90, 2144, 1764, 110, 378, and 78 cpm/l. The radioactivities at 6 and 72 hours after the starting point, as well as the backgrounds, are also shown. (NSA of Japan)

2249 SUMMARY OF MEAN RADIOACTIVITY IN RAIN COLLECTED AT FIXED TIME DAILY (TABLE 2, APRIL–JUNE 1966). (Japan Meteorological Agency, Tokyo). Taiki Hoshano Kansoku Seiseki, No. 45, 5-9(Mar. 1967). (In Japanese).

The mean values of radioactivity in rain water in $\mu\mu$Ci/cc at

6 and 72 hours after the starting point, for the respective days of the period from April to June 1966, are shown, which were obtained at Wakkanai, Sapporo, Kushiro, Sendai, Akita, Tokyo, Hachijo-jima, Wajima, Osaka, Yonago, Mutotomisaki, Fukuoka, and Kagoshima. The maximum values for 6 and 72 hours are 0.2 and 0.1 μμCi/cc, respectively, for April; 6.0 and 2.3 μμCi/cc for May; and 1.2 and 1.0 μμCi/cc for June. The amounts of precipitation in mm in the preceding 24 hours are also shown. (NSA of Japan)

2250 MEASUREMENTS OF TEMPORARY STANDARD SAMPLE (U_3O_8) AT EACH STATION (TABLE 1, APRIL–JUNE 1966). (Japan Meteorological Agency, Tokyo). Taiki Hoshano Kansoku Seiseki, No. 45, 1–4(Mar. 1967). (In Japanese).

The measured values of U_3O_8 in cpm/day and its monthly per-day mean during the period of April to June 1966, obtained at each station of the following locations are given: Wakkanai, Sapporo, Kushiro, Sendai, Akita, Tokyo, Hachijo-jima, Wajima, Osaka, Yonago, Murotomisaki, and Fukuoka. The monthly per-day mean-values for April, May and June for these stations are respectively: 5336, 5833 and 5819 cpm; 5025, 5140 and 5150 cpm; 5571, 5621 and 5585 cpm; 5787, 5665 and 5677 cpm; 6064, 6114 and 6063 cpm; 5725, 5634 and 5530 cpm; 5977, 5925 and 5950 cpm; 5728, 5860 and 5761 cpm; 6035, 5971 and 5931 cpm; 5756, 5422 and 5502 cpm; 5925, 5921 and 5945 cpm; and 6185, 6160 and 6117 cpm. (NSA of Japan)

Mineralogy and Exploration

Refer also to abstracts 2191, 2194, 2198, 2199, and 2201.

2251 URANIUM FOR POWER GENERATION. Martensson, M. (Aktiebolaget Atomenergi, Stockholm). Tek. Tidskr., 40: 987-92(Nov. 1967). (In Swedish).

Four different forecasts on uranium demand to 1980 are discussed. Figures on uranium supply in reasonably assured reserves and possible additional resources are given. The reserves and resources are categorized in three price categories: 5 to 10, 10 to 15, and 15 to 30 $/lb uranium concentrate, U_3O_8. It is regarded that there will be no shortage of uranium until 1980, even if no breeder reactors are in operation at that time. But the production capacity of the existing mines will be insufficient. New resources must be traced and opened. This will cause a price increase of uranium concentrate. (SWED)

2252 CONTRIBUTIONS TO THE EXPLORATION OF URANIUM DEPOSITS. Lungu, A. Stud. Cercet. Geol., Geofiz., Geogr., Ser. Geofiz., 4: 113-23(1966). (In Rumanian).

Gamma methods of U exploration are discussed. These methods revealed a series of uranium mineralization areas. Laboratory and field experiments on the diminishing of gamma rays in both supergenesis areas and in the soil were conducted. In the laboratory, sand and water were used as attenuating agents, and Geiger–Mueller-type counters and NaI crystal scintillometers were employed. (J.C.W.)

2253 MINERAL CONSTITUENTS AND BED FORMATIONS IN FIBROUS AGGREGATES OF THE CARBONACEOUS SUBSTANCE ("THUCHOLITH") FROM THE WITWATERSRAND CONGLOMERATES. Schidlowski, Manfred (Univ., Goettingen, Ger.). Contrib. Mineral. Petrol., 12: 365-80(1966). (In German).

Origin of U mineralization was studied by microscopic techniques. The footwall of the principal U-bearing conglomerates occurring within the Witwatersrand System (South Africa) is often characterized by a fibrous carbon or thucholite seam, ranging in thickness from <1 mm to several cm. The carbonaceous material has formed by radiolytic polymerization of originally mobile (especially gaseous) hydrocarbons percolating through the strata, the prerequisite for its formation thus being the presence of detrital uraninite within the heavy fraction of the individual reefs. The conspicuous columnar structure of the aggregates is explained as being due to growth at right angles to the bedding planes comparable with several other fibrous minerals. The association between U and other heavy minerals and carbonaceous matter must be particularly intimate, since the latter has accumulated in the lowermost footwall portions where the bulk of the heavy suite of the conglomerates is concentrated. Primary detrital constituents within the fibrous aggregates are pyrite, cobaltite, chromite, zircon, and iridosmine. Authigenic "recrystallized" heavy minerals are gold, linnaeite, chalcopyrite, galena, sphalerite, as well as traces of pyrrhotite. The detrital uraninite fraction is largely replaced by carbonaceous matter, i.e. the UO_2 particles are suspended in, and are being gradually digested by, the solid hydrocarbons. The carbonaceous matter is distinctly younger than the primary detrital minerals. On the other hand, the pseudohydrothermal recrystallization of the main mass of the gold (which originally also formed part of the heavy suite) must have taken place at a still later stage. The same applies to several genetically young sulfides as linnaeite, in part also to chalcopyrite. (BBB)

Oceanography

2254 (AED-C-25-01) BIBLIOGRAPHIEN ZUR KERNFORSCHUNG UND KERNTECHNIK. SEKTION 25. MARITIME RADIOLOGIE. Nummer 01. (Bibliographies in Nuclear Science and Technology. Section 25. Maritime Radiology. Number 01). (Zentralstelle fuer Atomkernenergie-Dokumentation, Frankfurt am Main (West Germany)). July 1967. 50p. (In English and German). Dep.

A bibliography on maritime radiology is presented comprising titles from conference papers, reports, journal literature, and books. An author index and subject index are also given. (J.S.R.)

2255 SINKING RATES OF RADIOACTIVE FALLOUT PARTICLES IN THE NORTH EAST PACIFIC OCEAN, 1961 TO 1962. Gross, M. G. (Smithsonian Institution, Washington, D. C. Univ. of Washington, Seattle). Nature (London), 216: 670-2 (Nov. 18, 1967). (RLO-1725-108).

The resumption of nuclear weapon testing in the atmosphere in September 1961 provided an opportunity to investigate the sinking rate of fallout particles. In the N. E. Pacific Ocean the beginning of the 1961 test series coincided closely with commencement of the winter storms with heavy rainfall, thus providing a mechanism for quickly depositing the fallout nuclides. Sediment samples were collected from the deepest localities and analyzed, using a computer programme, to obtain the abundance of ^{40}K, ^{58}Co, ^{65}Zn, $^{95}Zr/^{95}Nb$, $^{103}Ru/^{106}Ru$, ^{214}Bi, ^{51}Cr, and ^{141}Ce. The pair $^{95}Zr/^{95}Nb$ was selected as best for the study, because of its relative short half-life (65 days), its abundance in fallout, and its known association with particles in sea water. It appeared that the radioactive particles sank at rates of about 10 m/day. It was also noted that the observed decrease in $^{95}Zr/^{95}Nb$ activity with depth corresponded closely to the expected decrease resulting from a steady state injection with a sinking rate of 10 m/day. It was calculated that such a sinking rate corresponded to grains of 16μ diameter. (UK)

2256 A γ-RADIOMETER FOR THE CONTINUOUS RECORDING OF LOW-LEVEL CONTAMINATION OF SEAWATER. Morozov, V. I.; Petrusev, S. S.; Fedorovskii, Yu. P. At. Energ. (USSR), 23: 163-4(1967). (In Russian).

Determination of low concentrations of ^{137}Cs, $^{90}Sr + ^{90}Y$, $^{106}Ru + ^{106}Rh$, $^{95}Zr + ^{95}Nb$, ^{65}Zn, ^{60}Co, and ^{54}Mn in seawater requires highly-sensitive instruments; the sensitivity is limited by the background due to cosmic radiation and the ^{40}K content of the water. An instrument was developed, compensating for the γ radiation of ^{40}K; its operation was based on the continuous recording of the γ quanta by means of a two-channel discriminator, working in the 60-keV to 1.6-MeV, and 1.4 to 1.6-MeV ranges, with subsequent compensation of the ^{40}K background. The concentrations covered by the instrument ranged from 10^{-11} to 10^{-7} Ci/l. The background level at the time of measurement was 1 pulse/sec; before compensation, it was at least 8 pulses/sec. The instrument is recommended for use for oceanographic and geological research near the coastal shelf. (TTT)

2257 REGULARITIES OF THE RADIOACTIVE CONTAMINATION SPREADING IN THE OCEAN. Belyaev, V. I.; Kolesnikov, A. G.; Nelepo, B. A. (Marine Hydrophysical Inst., Kharkov). Izv. Akad. Nauk SSSR, Fiz. Atmos. Okeana, 3: 1092-1100 (Oct. 1967). (In Russian).

The results obtained in the Marine Hydrophysical Institute of the Ukrainian Academy of Sciences in the study of spreading of radioactivity from nuclear tests in seas and oceans were analyzed. The physical mechanism of radioactive penetration from the atmosphere into the ocean depths is discussed. Investigations revealed a far greater rate of penetration of radioactivity than has been considered before. Estimating the water's age by decay of radioactive elements while neglecting exchange in the ocean is shown to be inadequate. (tr-auth)

Seismology

Refer to abstract 2262.

ENGINEERING

Nuclear Explosions

2258 (AD-646627) APPROACH TO DEFINING POST-ATTACK RECOVERY MANAGEMENT CONCEPTS AND TECHNIQUES. Clark, Donald E.; Miller, Carl F.; Hopkins, George I. (Stanford Research Inst., Menlo Park, Calif.). Nov. 1966. Contract OCD-OS-63-149. 62p. CFSTI.

Potential postattack countermeasures, under the six general categories of protective, radiological, medical, ecological, economic, and social, are listed and discussed briefly. A functional approach to the development of postattack recovery management techniques based on current knowledge is suggested, and present developmental limitations are indicated. (auth)

2259 (AD-646858) EQUATIONS AND COMPUTER PROGRAM TO CALCULATE THE THERMAL HISTORY OF A DUAL-LAYERED PLATE SUBJECT TO THE THERMAL PULSE OF A NUCLEAR WEAPON. Progress Report. Heilferty, R. J.; Koch, J. E.; Cohen, M. L. (Naval Applied Science Lab., Brooklyn, N. Y.). Dec. 28, 1966. 80p. (PR-3).

A generalized computational technique to be used in the calculation of the temperature profiles and histories in single and dual layered plates exposed to thermal pulses of nuclear explosions is presented. The program was written to accommodate materials whose thermophysical properties are an arbitrary function of the local temperature. In addition, quite general boundary conditions are permitted. Sample calculations are presented in order to illustrate the nature of the output format. (auth) (TAB)

2260 (CONF-671022-1) THE EFFECTS OF WEATHER ON THE OPTICAL DETECTION OF DEEP SPACE NUCLEAR BURSTS. PART I. Green, W.; Frank, R. (Plesset (E. H.) Associates, Inc., Santa Monica, Calif.). [nd]. 8p. (C-83-58103). Dep.

From Annual Meeting of the Optical Society of America, Detroit, Mich.

A method of computing the direct and scattered light flux received by a ground-based detector from a fluorescent light source in the earth's upper atmosphere is discussed. This light source is assumed to be caused by the arrival of X rays that originate from a deep-space nuclear detonation. The main purpose of the study was to determine the effect of the scattered light flux on the time history of the signal received by the detector. (auth)

2261 (CONF-671029-1) PUBLIC HEALTH ASPECTS OF THE CIVILIAN APPLICATIONS OF NUCLEAR EXPLOSIVES (PLOWSHARE) PROGRAM. Barth, D. S. (Public Health Service, Las Vegas, Nev. Southwestern Radiological Health Lab.). Sept. 1967. Contract SF-54-373. 12p. Dep. CFSTI.

From International Health Symposium, Miami Beach, Fla.

The work being carried on within the Plowshare Program is presented. This includes an introduction to studies in the categories of research and development, excavation experiments, scientific research experiments and underground engineering experiments. Particular attention is devoted to public health aspects of the excavation and the underground engineering applications. Potential hazards which may be associated with ground shock as well as those related to nuclear radiation are discussed in general terms. An inventory of some radionuclide activities expected to be released from nuclear cratering events of useful magnitude is presented. (auth)

2262 A SURVEY OF COMPLAINTS OF SEISMIC-RELATED DAMAGE TO SURFACE STRUCTURES FOLLOWING THE SALMON UNDERGROUND NUCLEAR DETONATION. Power, Dean V. (Univ. of California, Livermore). Bull. Seismol. Soc. Amer., 56: 1413-28(Dec. 1966). (UCRL-14110(Rev.1)).

Following Salmon, the underground nuclear experiment in Mississippi, numerous unexpected complaints of damage were received from residents living 15 to 40 km away. The claimed damage is mostly cracks in plaster, stucco, and masonry. Ground motion at these ranges was within the predicted safe limits, with peak surface-particle velocities roughly an order of magnitude below the 5 to 10 cm/sec previously accepted as the threshold for damage. It is shown that a 5 cm/sec damage threshold is not descriptive of this area, and revised damage criteria need to be formulated that take into consideration geology, frequency spectrum, and other factors in addition to surface particle velocity. The claimed damage is similar to that normally found in Mississippi homes where it is attributed to poor foundation soils. The triggering by Salmon of naturally occurring settlement cracks is suspected, but the physics of the process is not yet fully understood. Further complications in the survey are introduced by local sociology and psychology and public relations factors. (auth)

Facilities and Equipment

Refer also to abstracts 2589, 2885, 2889, 2980, 2984, 2997, 3972, 3980–3982, 3984, 3989, and 3992.

2263 (EUR-3611f) INSTALLATION PILOTE DE SEPARATION DU ^{137}Cs PAR PRECIPITATION. (Pilot Plant for Separation of ^{137}Cs by Precipitation). Fradin, J.; Quesney, M. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). June 29, 1967. 174p. (In French). Dep.

A pilot plant was constructed in order to test the value of chemical separation procedures and to obtain technological information on the chemical apparatus and materials employed. Another aim was to separate a significant quantity of cesium-137 for the study and development of the fabrication of sealed sources. The chemical process, assembly and protection of the plant, the equipment used, and the measurement, control, regulation and monitoring techniques employed are described. (auth)

2264 (EUR-3613f) PROJET DE CELLULE PILOTE D'EXTRACTION PAR SOLVANT DU STRONTIUM 90. (Design of a Pilot Cell for ^{90}Sr Extraction by Solvent). Fradin, J. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Sept. 1967. Contract 025-62-10 RISF. 140p. (In French). Dep.

The design of a pilot plant for the study of the separation of the elements contained in fission products is presented. This plant will serve as a basis for the design of a unit for the production of strontium-90 and rare earths for treating effluent solutions from an irradiated fuel reprocessing plant. A description of the process and an examination of the safety precautions, the equipment, and the controls, measurements and monitoring and regulating devices are included. (auth)

2265 (GEAP-5524) RADIAL VANE STEAM SEPARATOR DEVELOPMENT. Eighth Quarterly Report, Phase II, November 1966–June 1967. Moen, R. H. (General Electric Co., San Jose, Calif. Atomic Power Equipment Dept.). July 1967. Contract AT(04-3)-189. 57p. (EURAEC-1931). Dep. CFSTI.

Work Performed under United States–Euratom Joint Research and Development Program.

The KRB radial vane separator design numbers were modified taking into account the operating data obtained during startup of the KRB reactor. Equations for flow and pressure drop throughout the separator were set up. Steady-state performance of KRB with the radial vane separator in place was predicted. The separator mechanical design was continually revised to reduce cost and manufacturing time; and the analysis of transient, safety, and licensing problems was begun. In addition, the natural frequency of the model separator (FCRV-4) in the Large Air-Water Test Facility in air and in water was measured, vibration of this unit during two-phase air-water flow was measured, the natural frequencies and vibration modes of the KRB reactor with the radial vane separator in place were predicted, and analysis of the vibration problem was begun. During the last week of the period planning for the model separator tests at reactor conditions in the new Large Steam-Water Test Facility were begun. (auth)

2266 (IPP-1/68) UNTERSUCHUNGEN AN SCHNELL OEFFNENDEN ELEKTROMAGNETISCHEN GASEINLASSVENTILEN. (Investigations of Fast-Acting Electromagnetic Gas-Inlet Valves). Brinkschulte, H.; Finkelmeyer, H.; Hofmann, G.; Makios, W.; Muntenbruch, H.; Pecorella, F. (Institut fuer Plasmaphysik, G.m.b.H., Garching (West Germany)). July 1967. 36p. (In German). (IPP-3/56). Dep.

Some plasma physics experiments require the admission of a definite quantity of gas into a discharge vessel during a very short time interval. For such applications some slightly different valves were built and their operating characteristics tested. Because of varying experimental conditions, different requirements were placed upon these valves, and their operation was tested by methods well suited to these requirements. The valves, of metallic construction, are operated using the magnetic fields produced by coils. The operation of the valves was examined with a photomultiplier (which measured the light admitted through the valve opening) and a 4 mm microwave apparatus (making use of the Doppler effect). Minimum time required for opening was about 30 μsec, and the time during which the valve remains open was 50 to 3000 μsec. By measuring the pressure increase, the total number of particles admitted (10^{17} to 10^{19} and 10^{21} to 10^{23} respectively) was determined as a function of the valve parameters. The behavior of the gas as it streams into the vacuum vessel,

which is important for plasma experiments, was investigated with a Mach–Zehnder interferometer, a piezo-electric probe, and an ionization gage. Comparison of the measured and calculated values gave good agreement between experiment and theory, and enables one to recognize the main characteristics of such valves. (auth)

2267 (K-L-6181) GRAVIMETRIC STANDARD FOR PRIMARY GAS FLOW MEASUREMENTS. Collins, W. T. (Oak Ridge Gaseous Diffusion Plant, Tenn.). Oct. 18, 1967. Contract W-7405-eng-26. 13p. (CONF-671101-4). Dep. CFSTI.

From Annual Meeting of the American Society of Mechanical Engineers, Pittsburgh, Pa.

A gravimetric standard consisting of a balance, weighing bottles, bottle valve, sealing device, control orifice, and diverting valves is used for primary gas flow measurement. The calibration and precision of the standard are given. (F.S.)

2268 (MND-3288) HEAT PIPE DESIGN MANUAL. Frank, S.; Smith, J. T.; Taylor, K. M. (Martin-Marietta Corp. [Baltimore, Md.] Feb. 1967. 126p.

Results of a program for compiling materials properties in a form useful to heat pipe designers are presented. For each potential heat pipe working fluid considered the properties presented in both engineering and scientific units as a function of temperature are vapor pressure, surface tension, density of liquid, density of vapor, viscosity of liquid, viscosity of vapor, thermal conductivity of liquid, and latent heat of vaporization. Useful groups of parameters presented are liquid transport factor, vapor transport factor, ratio of kinematic viscosities, and wicking height factor. Where possible, the pertinent properties of water, sodium, cesium, and ammonia have been plotted over the entire range of temperatures from melting point to critical point. In those instances where authoritative data could not be found for certain properties over the useful range (presumably from about 0.1 to 10 atm of vapor pressure) estimation by calculation and/or extrapolation was used and is so indicated. Melting, boiling and critical temperatures have been indicated on the individual graphs for convenient reference. (J.C.W.)

2269 (NYO-3237-8) EXPERIMENTAL TEST AND EVALUATION OF A GAS-BEARING BRAYTON CYCLE TURBOCOMPRESSOR. Quarterly Progress Report, September 1, 1966–December 31, 1966. Meacher, J. S. (Mechanical Technology Inc., Latham, N. Y.). Oct. 6, 1967. Contract AT(30-1)-3237. 75p. (MIT-67TR74). Dep. CFSTI.

A feasibility study was made of the application of gas-lubricated bearings to closed-system gas-turbine machinery. A Brayton cycle gas generator (turbocompressor) utilizing self-acting gas bearings was designed, built, and tested. Self-sustained closed-loop operation of the turbocompressor, using its own cycle gas as the bearing lubricant, was achieved. The turbocompressor was successfully operated in nitrogen. The turbocompressor was operated under "no-load" and "load" conditions in argon at turbine inlet temperatures up to 1355 F. A new hydrostatic-hydrodynamic thrust bearing was tested in several modes of operation. The bearing load capacity in the hydrodynamic mode fell short of theoretical prediction by a significant amount, apparently due to thermal distortion. The hydrostatic load capacity was in close agreement with theory, and was significantly greater than that of the previous bearing design. The new thrust bearing was also operated in a "self-sustained hybrid" mode, wherein the hydrostatic orifices were supplied with compressor discharge gas. The bearing successfully supported the turbocompressor rotor in this mode, over the entire design range of steady-state turbocompressor operation. Transient tests of the turbocompressor were also conducted successfully with "self-sustained hybrid" operation of the thrust bearing. The thrust bearing was also run hydrodynamically with the ID of the bearing completely sealed. Only a very minor increase in load capacity resulted from sealing the bearing ID. Tests of the bearing with a pressure differential across the thrust runner were inconclusive due to limitations in the pressurizing system. The maximum ΔP achieved was 0.35 psi; turbocompressor bearing clearance at design speed operation was increased about 0.2 mil by this ΔP. The test program was concluded with a successful eight hour run at design speed and higher-than-design turbine inlet temperature. Bearing performance was completely satisfactory during this run, and the rotor-bearing system appeared to be unaffected by the overdesign turbine inlet gas temperature. (auth)

2270 (NYO-3237-9) EVALUATION OF THE EFFECT OF CHANGING CYCLE GAS ON THE PERFORMANCE OF A CLOSED-LOOP BRAYTON CYCLE TURBOCOMPRESSOR. Emerson, T. P. (Mechanical Technology Inc., Latham, N. Y.). Oct. 18, 1967. Contract AT(30-1)-3237. 59p. (MTI-67TR-81). Dep. CFSTI.

Test data have been obtained from a closed-cycle turbocompressor-loop system using both N and Ar as the cycle working gas. Change in working gas was made to study changes in performance of the turbocompressor. It was found that when the system working fluid is changed to a thermodynamically different gas, matching of the turbine to the compressor changes. This means that for given turbine and compressor inlet temperatures, the compressor will move to a different operating point on its characteristic map and therefore will have a different efficiency. To cause the compressor to move back to its original operating point, it is necessary either to change the turbine inlet temperature or to change the turbine nozzle area. It is possible to predict analytically the change in compressor operating point from the thermodynamic properties of the gases. Analysis of the compressor performance shows that compressor efficiency is primarily a function of diffuser and inducer gas angles, with Mach number playing a much less significant role. This is because the Mach number is low in this design. As Mach number approaches unity, its effect would be expected to be more significant. The compressor characteristic performance curves (flow parameter versus pressure ratio) can be analytically predicted with a good degree of accuracy for a change in working gas. The turbocompressor used for the test program was designed for a specific set of N operating conditions. Because of the turbine-to-compressor matching change, and a maximum turbine inlet temperature limitation, it was not possible to experimentally operate the turbocompressor at the condition of highest compressor efficiency in Ar. However, at the somewhat lower performance levels, the Ar test data show reasonably good agreement with the analytically predicted Ar efficiency values based on the known compressor efficiency in N. The turbine performance in Ar was as predicted. There was no significant change in turbine efficiency (relative to N operation) when the turbocompressor was operated in Ar. (F.S.)

2271 (ORNL-TM-1987) ANALYTICAL SOLUTIONS TO EDDY-CURRENT PROBE COIL PROBLEMS. Dodd, C. V.; Deeds, W. E. (Oak Ridge National Lab., Tenn.). Nov. 1967. Contract W-7405-eng-26. 41p. Dep. CFSTI.

Solutions have been obtained for axially symmetric eddy-current problems in two configurations of wide applicability. In both cases the eddy currents are assumed to be produced by a circular coil of rectangular cross section, driven by a constant amplitude alternating current. One solution is for a coil above a semi-infinite conducting slab with a plane surface, covered with a uniform layer of another conductor. This solution includes the special cases of a coil above a single infinite plane conductor or above a sheet of finite thickness, as well as the case of one metal clad on another. The other solution is for a coil surrounding an infinitely long circular conducting rod with a uniformly thick coating of another conductor. This includes the special cases of a coil around a conducting tube or rod, as well as one metal clad on a rod of another metal. The solutions are in the form of integrals of first-order Bessel functions giving the vector potential, from which the other electromagnetic quantities of interest can be obtained. The coil impedance has been calculated for the case of a coil above a two-conductor plane. The agreement between the calculated and experimental values is excellent. (auth)

2272 (ORNL-TM-2009) THERMAL NEUTRON FLUENCE MEASUREMENTS IN THE DOSAR FACILITY THERMAL PILE. Poston, J. W.; Crase, K. W.; Robinson, E. M. (Oak Ridge National Lab., Tenn.). Nov. 1967. Contract W-7405-eng-26. 13p. Dep. CFSTI.

A series of thermal neutron fluence measurements were made in the DOSAR Facility thermal pile, including the measurement of the fluence distribution in the pile, effects of foil spacing upon the fluence measurement, and the determination of the cadmium ratio (bare gold foil activity/cadmium-covered foil activity) at specific areas within the pile. (auth)

2273 (RFP-977) PLUTONIUM HANDLING SAFETY ANALYSIS OF THE ROCKY FLATS NUCLEAR SAFETY FACILITY. Hunt, Douglas C.; Tuck, Grover (Dow Chemical Co., Golden, Colo. Rocky Flats Div.). Nov. 8, 1967. Contract AT(29-1)-1106. 29p. Dep. CFSTI.

The accident potentials associated with the most hazardous types of fissile-material operations in the Rocky Flats Nuclear Safety Facility were estimated. The accident potential of several types of Pu experiments were considered. An excursion of a large array of 400 one-meter long by 3.1 cm dia Pu cylinders uniformly spaced within a 213.9 cm square was considered in detail and found to be the potential for the maximum-credible Pu accident but within the containment ability of the facility. The MCA of U and Pu were compared. It was found that the Pu accident is the most hazardous and thus is the limiting MCA of the Rocky Flats Nuclear Safety Facility. (F.S.)

2274 (RPI-3820-1) STUDY OF THE EFFECT OF HYDROSTATIC PRESSURE ON SELF-DIFFUSION RATES IN HEXAGO-

NAL METALS. Progress Report. Gilder, H. Michael (Rensselaer Polytechnic Inst., Troy, N. Y.). Oct. 1967. Contract AT(30-1)-3820. 6p. Dep. CFSTI.

Equipment was designed, constructed or acquired for measurement of the effect of hydrostatic pressure on self diffusion rates in hexagonal metals. (F.S.)

2275 (RT/EL-(67)3) COMPLESSO PER MISURE DI TERMOLUMINESCENZA. (Equipment for Measurement of Thermoluminescence). Arabia, M.; Caserta, G.; Fioroni, F. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). 1967. 13p. (In Italian). Dep.

Equipment designed to measure thermoluminescence of organic and inorganic materials is described. The assembly can be used to irradiate samples at the liquid nitrogen temperature to warm it up subsequently, at a constant rate to 100°C, and to analyze and record the light emitted from the sample during warming. (auth)

2276 (UCRL-50317) A HERMETICALLY SEALED, HIGH VACUUM GLASS VALVE. Frazer, Jack; Stump, Ronald K. (California Univ., Livermore. Lawrence Radiation Lab.). Sept. 25, 1967. Contract W-7405-eng-48. 4p. Dep. CFSTI.

A hermetically sealed high-vacuum glass valve was designed to automate the vacuum analytical system in a chemistry laboratory using a computer. The valve incorporates a glass body, stainless steel bellows, Teflon plunger and a Viton "O" ring. It is automated by means of a piston and plunger. The shortcomings of a greased stopcock are overcome. The accuracy of vacuum analytical techniques and the utility of vacuum synthesis systems are provided by the valve. (F.S.)

2277 (UCRL-50318) AN AUTOMATED, VARIABLE-TEMPERATURE CONDENSATION TRAP. Stump, Ronald K.; Frazer, Jack W. (California Univ., Livermore. Lawrence Radiation Lab.). Sept. 25, 1967. Contract W-7405-eng-48. 4p. Dep. CFSTI.

A variable-temperature cold-trap utilizing liquid N as a low temperature coolant and a resistance thermometer as a detector for temperature control was designed for use in vacuum analytical and synthesis chemistry. The trap consists of a glass U-tube with both legs encased in Cu tubing. Temperature can be varied from −180°C to 100°C. A semi-automatic control is provided or the trap may be computer controlled. (F.S.)

2278 (UCRL-70720) SAFETY IN FLOORING AND OTHER WALKWAY SURFACES. Sykos, Michael; Gaskill, J. R. (California Univ., Livermore. Lawrence Radiation Lab.). Oct. 25, 1967. Contract W-7405-eng-48. 13p. (CONF-671020-1). Dep. CFSTI.

From National Safety Congress, Chicago, Ill.

Safety in flooring and other walkway surfaces was studied in relation to the following types of safety hazards: mechanical, including slips, trips and falls; contamination, both chemical and radioactive; fire and explosion; and electrical. Recommendations are made for the design, selection of materials, and maintenance of walkways to meet the safety requirements of particular installations. (L.C.L.)

2279 (WAPD-Trans-76) SOME PROBLEMS AND NEW WELDING TECHNIQUES APPLIED TO THE CONSTRUCTION OF NUCLEAR REACTORS. Foulquier, Henri. Translated for Bettis Atomic Power Lab., West Mifflin, Pa., from Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), No. 63, 32-43(1967). 27p. Dep. CFSTI. JCL $2.60 fs, $1.01 fs.

Problems in welding encountered chiefly in the design of the EL4 heavy water–gas reactor are discussed. The problems included welding the ends of the Zr alloy force tubes to the orthocylindrical stainless steel tank bottoms, performance of overlap welds, fabrication of double bottoms, and remotely controlled welding machines. (F.S.)

2280 METERING OF STEAM-WATER TWO-PHASE FLOW BY SHARP-EDGED ORIFICES. James, Russell (Department of Scientific and Industrial Research, Taupo, N. Z.). Proc. Inst. Mech. Eng. (London), 180: 549-72(1965-66).

When the stagnation enthalpy, or alternatively the dryness fraction, at the orifice is known, it is shown that the mass flow rate can be approximately determined. For the case where a stream–water mixture passes through a pipeline to the atmosphere or to a low-pressure receiver so that critical flow occurs at the outlet, both the mass flow rate and the stagnation enthalpy may be approximately evaluated using an orifice meter in series with a pressure tapping located at the point of critical flow. In this case, a trial-and-error method is necessary. The experimental results described were within a range of dryness fractions from 1 to 56%, orifice pressures from 75 to 275 psia, differentials from 15 to 780 mmHg under water, and flow rates from 54,700 to 508,000 lb/hr. Orifices of 5.591 and 6.615 in. dia were installed in 7.9 in. dia pipes which were equipped with radius (D and D/2) taps. The method employs a correlation between the homogeneous dryness fraction x and a corrected dryness fraction x_m necessary for evaluating the two-phase density used in the conventional single-phase meter equation. (auth)

2281 ACTIVATION OF MACHINE COMPONENTS AND MECHANISMS BY CHARGED PARTICLES USED AS A BASIS FOR CONTINUOUS WEAR CONTROL. Postnikov, V. I.; Moiseev, V. Ya. At. Energ. (USSR), 23: 158-9(1967). (In Russian).

An activation method was developed for the continuous measurement of the wear of machine components under normal operating conditions without requiring any special shielding. The wear was determined by the decrease of the activity of the surface layer, comparing the activity data with those obtained with corresponding portions of the test sample and a simultaneously irradiated reference specimen. Cyclotron-accelerated charge particle beams were used for the activation. The tests were carried out with an iron alloy piston case exposed to a 13.4-MeV deuteron beam. The yields of the (d,p) reactions were determined by means of the Maksimov formula. Gas-discharge and scintillation detectors were used to measure the γ radiation emitted by the activated components. The depth was measured by determining the activity after removing 3 to 5 μ of the material by abrasion, comparing the values with known activities of ^{54}Mn, ^{58}Co, and ^{57}Co. The theoretical depth of the activated layer was 285 μ; the experimental values lay between 244 and 280μ. (TTT)

2282 INFLUENCE OF LUBRICANT COMPRESSIBILITY ON THE PERFORMANCE OF THE 120 DEGREE PARTIAL JOURNAL BEARING. Gunter, E. J. Jr. (Univ. of Virginia, Charlottesville. Franklin Inst., Philadelphia). J. Lubric. Technol., 89: 473-82(Oct. 1967).

The characteristics of the 120° gas bearing as the compressibility parameter Λ is increased from 0 to ∞ are discussed. At low values of Λ and light loads, the gas bearing behaves as an incompressible lubricated bearing. Curves are developed to show under what conditions of bearing loading, film thickness, and speed the partial gas bearing may be treated by the incompressible theory. The compressibility parameter Λ has a considerable effect on the proper selection of the shoe pivot position and bearing clearance ratio for both maximum load capacity and minimum coefficient of friction. It is shown that the bearing clearance ratio and pivot location can vary considerably and still maintain close to optimum conditions at low compressibility numbers. At higher compressibility numbers, the choice of pivot location has a substantial effect on the bearing load capacity and coefficient of friction. Also discussed are the optimum design ranges of the compressibility number Λ. (auth)

2283 RADIATION-CHEMICAL INSTALLATION FOR THE THERMAL RADIATIVE VULCANIZATION OF TIRES USING SPENT FUEL ELEMENT AS SOURCE. Borisov, V. A.; Drozdov, V. E.; Lisov, G. V.; Ryabukhin, Yu. S.; Suroegin, L. M.; Lesnichii, V. E.; Zaharova, I. M.; Vasil'ev, A. G.; Dunacy, L. M. At. Energ. (USSR), 23: 141-2(1967). (In Russian).

A test stand which included a radiation source consisting of spent fuel elements was built to examine the possibility of using such a system on an industrial scale for the vulcanization of tires. The radiation-chemical installation consisted of a leak tight cylindrical container holding six tires which were separated by means of metallic spacers to prevent warping. Before irradiation, the container was evacuated and refilled with argon to a pressure of 1.05 to 1.1 atm. The 18 fuel elements were distributed on the periphery of a 900-mm dia. support which could be lifted in the desired position near the tires for irradiating them. Because of the differences in the activity distribution the position of the tires was changed during the experiment. The activity of the elements ranged from 2600 to 5100 gram-equivalent of radium. The mean activity of the source and its activity at any given time needed to calculate the reproducibility of the system were determined from graphs published previously. Road tests of the irradiated tires on a Moskvich car indicated that some of the properties of the tires were improved. (TTT)

2284 THE MULTIPLE-CHAMBER ELECTRON-BEAM FURNACES AND THEIR APPLICATIONS OF THE (EAST GERMAN) HENNINGSDORF WORKS. Schonberg, Helmut; Schiller, Siegfried. Neue Huette, 12: 146-50(Mar. 1967). (In German).

Discusses the development of the multiple-chamber electron beam furnaces EMO 60 (60 kw), EMO 200 (200 kw) and EMO 250 (250 kw), the latter being the first electron beam furnace specifically designed for the melting of steel. It is able to produce ingots weighing 12 tons, 800-mm thick and 3-m long. In a three-turn operation the annual capacity is 2000-3000 tons. Technical data (number of molds, mold diameter, length, specific power requirements, net melting time, duration of melting cycle, annual produc-

tion capacity, time of cooling to 400 C.) are tabulated for steel, Ti, Nb, Mo and Ta. The design and mode of operation of the furnaces are presented in detail. (Rev. Met. Lit.)

2285 FINAL DESIGN OF SODIUM-HEATED, MODULAR STEAM GENERATORS FOR THE SODIUM COMPONENT TEST INSTALLATION (SCTI). Casey, D. F. (Atomics International, Canoga Park, Calif.). Contract AT(11-1)-Gen-8. Nucl. Eng. Design, 6: 223-35(1967).

The design and operation criteria are described for a 37-tube, modular-type, low-temperature evaporator and high-temperature superheater for testing in the Sodium Component Test Installation (SCTI). The mechanical design details and outline of performance analysis are discussed. The evaporator and superheater modules, when combined, would be capable of generating 2400 psi, 1050°F steam. (auth)

2286 ELECTROSLAG WELDING HELPS ESCO FABRICATE LARGEST STAINLESS NUCLEAR PUMPS. West. Mach. Steel World, 58: No. 3, 29-30(Mar. 1967).

The largest stainless steel nuclear pump case weighs 85,000 lbs; it is 8 ft high, 10 ft in dia and wall thickness varies from 8-18 in. Material composition is equivalent to 316 stainless steel (8% Ni, 18% Cr, and 2-3% Mo). Case is cast in four sections which are welded together by electroslag welding process. Development of welding technique for case is described. Welds are made with straight sided weld gap, 1¼ in. wide; molten slag is contained by two Cu shoes which move automatically, giving required contour to weld. Entire casting and all welds are inspected by betatron radiography technique. (Rev. Met. Lit.)

2287 STEAM TURBINE CLEARANCE MEASUREMENT BY GAMMA RADIATION. Loffler, H.; Richter, S. (Univ., Dresden). Maschinenbautechnik, No. 1, 19-24(1967).

A device for measuring and controlling the radial clearance of an experimental turbine is described. A watercooled scintillation counter, mounted on the turbine, serves for measuring radiation intensity. Cesium-137 is used as emitter. It was found that the radial clearance decreases in the tested plane at switch on, and increases at full stop. The radiometrically determined, typical play can be measured with a degree of precision of about ±0.9 percent. Mechanical play measurement, which is necessary for plotting the calibration curve, yields a total error of 1.3%. The radiometric clearance measuring instrument described is found suitable for turbine unit control. (JPRS)

2288 COMPUTER TECHNIQUES IN γ SPECTROMETRY. Dean; Phillip N. (Los Alamos Scientific Lab., N. Mex.). pp 617-26 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Discussions are presented concerning the techniques used for the various types of analysis. Indications of the accuracy of the methods are included. The programs are categorized as quantitative and qualitative. Qualitative refers to determining the number and energy of all photopeaks in complex spectra, while quantitative refers to determining the absolute amounts of each component in complex spectra. Discussions of codes written for use in analysis of γ spectra are included. (J.R.D.)

2289 METHOD AND DEVICE FOR RELEASING ELECTRIC ENERGY. Prost, Gerard; Sole, Jean (to Commissariat a l'Energie Atomique). British Patent 1,090,529. Nov. 8, 1967. Priority date Nov. 9, 1965, France.

A method for releasing electric energy which is stored in a conducting loop circuit capable of assuming the normal state or the superconducting state is described. The loop circuit is covered over a part of its length with an external metallic sheath which has a low electrical resistance compared with the resistance of the circuit in the normal state and which is in electrical contact with the circuit. A load circuit is coupled to the sheath by means of terminal conductors. The conducting circuit is opened by means of a switch placed in a zone which is not covered by the sheath. In order to bring the conducting circuit to the superconducting state, the circuit is immersed in liquefied gas which is contained in a cryostatic vessel. (J.H.M.)

2290 IMPROVEMENTS IN APPARATUS FOR THE IRRADIATION OF BIOLOGICAL SPECIMENS. Divita, Giulio; Haybittle, John Leslie. British Patent 1,086,721. Oct. 11, 1967. Filed Mar. 5, 1963.

The complete specifications of an apparatus designed for ^{60}Co γ irradiation of biological specimens such as mice or other small animals, tissues, cells, and plants in ecosystems, are described. The apparatus is compared with four existing systems of ^{60}Co irradiation, i.e., telecobalt therapy, concentric systems, hot rooms, and gamma fields. (B.H.S.)

Heat Transfer and Fluid Flow

Refer also to abstracts 2259, 2268, 2451, and 2903.

2291 (AI-CE-TDR-1038) HWOCR DUAL CHANNEL CROSS FLOW STUDIES. Pekrul, P. J.; Cassidy, R. B. (Atomics International, Canoga Park, Calif. Combustion Engineering, Inc., Windsor, Conn.). May 20, 1966. 34p. Dep. CFSTI.

Three methods were evaluated for the measurement of cross flow. Both the resistance and correlation method yielded the cross flow ratio Q_x/Q_t. The resistance method takes less time to run and analyze and produces more data points than the correlation method. The correlation method is not applicable to multi-channel tests. The model method could not be properly evaluated because of the relatively large cross flow in the dual channel. This method remains as a tool for analyzing experimental results. The Q_x/Q_t ratio for the average of the 4, 6 and 8 gpm flow rates and an average gap of 4 mils is: $Q_x/Q_t = 0.294 \pm 0.0371$. The quantitative cross cross flow M at a flow velocity of 26 fps and water at 102°F in the dual channel is: M = 0.326 #/sec/ft ± 12.6%. (auth)

2292 (CONF-660120) THERMAL DESIGN OF CONDENSERS: REPORT OF A MEETING AT NEL, 5TH JANUARY 1966. (National Engineering Lab., Glasgow (Scotland)). Jan. 1967. 99p. (NEL-270). Dep.

A meeting held to allow an exchange of views and experience on thermal design between people interested in the research, design, manufacturing, and user aspects of condensers is reported. Discussions were included on prediction of required surface area and pressure gradients in condenser tube banks, regenerative and by-pass lanes, and air cooler and sizing of air ejector systems. (auth)

2293 (GEAP-5480) TWO-PHASE FLOW STRUCTURE IN A NINE-ROD CHANNEL, STEAM-WATER AT 1000 PSIA. Final Summary Report. Janssen, E. (General Electric Co., San Jose, Calif. Atomic Power Equipment Dept.). June 1967. Contract AT(04-3)-189. 85p. Dep. CFSTI.

Equipment was developed for making experimental determinations of the flow structure in a multirod test channel with steam-water at 1000 psia flow vertical upward. The instrumentation includes three isokinetic probes, three Preston shear probes, and porous wall segments on three of the rods: all of these instruments are located at the exit end of the heated length. A model was developed for interpreting the isokinetic data. For this model, isokinetic conditions exist at $P^* = -0.275$. Calibration data for the shear probes fit the Preston tube calibration curve for single phase flow. (auth)

2294 (KFK-604) "ALLGEMEINE SPALTGLEICHUNG" FUER DEN WAERMEDURCHGANG BRENNSTOFF-HUELLE IN KERNBRENNELEMENTEN MIT TABLETTENBRENNSTOFF. ("General Fission Equation" for Heat Transfer in Fuel Cans in Nuclear Fuel Elements with Pellet Fuels). Kaempf, H. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Angewandte Reaktorphysik). June 1967. 16p. (In German). Dep.

A general fission equation for the heat transfer in fuel cans was determined on the basis of a fission model for the transition zone between fuel and can. In this equation the temperature decrease in the gas gap is represented as a function of the gap width, the can internal temperature, the can internal radius, the rod efficiency, the type of gas, and the absorption capacity of the internal surface of the fuel and the can. For a relative small gap width a heat transfer number independent of the temperature decrease is obtained. The fission equation and approximations for Na-2 conditions, He in the gas gap, and black surfaces were numerically evaluated and represented graphically. The heat transfer number was represented as a function of the gap width with temperature and type of gas as parameters. The ladder curves are sufficiently valid in the Na-2 conditions for gap width smaller than 30 microns. The effect of the type of gas and the absorption capacity was considered for two limiting cases. (tr-auth)

2295 (KFK-638) DER WAERMEDURCHGANG DURCH KOHLEFILZE. (Heat Transfer Through Carbon Felt). Reiss, F.; Ripfel, H.; Schretzmann, K. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Neutronenphysik und Reaktortechnik. Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Angewandte Kernphysik). July 1967. 39p. (In German). Dep.

Carbon felts now available are a handy material for thermal insulations usable to the highest temperatures. For this purpose they may be used in high temperature furnaces, in arrangements for inductive melting, with hot neutron sources, in arrangements for the direct conversion of heat into electricity, with nuclear

heat sources, and with heat pipes. Based on theoretical considerations it is demonstrated that the heat passage through the strongly inhomogeneous felts is suitably described with the help of a "heat current function", an integral of a quantity corresponding to the common thermal conductivity. The heat current functions of carbon felts in vacuum were measured between 1000°C and 3000°C. The heat current was perpendicular to the surface of the felts. Moreover, in one type of felt it was measured down to −180°C and in helium at 380 torr. The effects of the inhomogeneous surface temperature of the heat source, of the finite temperature of the heat sink, and of a mechanical compression were eliminated. Formulas are given to calculate the heat power from the heat current function and the form and size of the insulations. (auth)

2296 (LA-3777) MONTE CARLO METHODS FOR THE SOLUTION OF HEAT TRANSFER PROBLEMS, INCLUDING HYBRID COMPUTER TECHNIQUES FOR MONTE CARLO. Treiman, Marilyn (comp.) (Los Alamos Scientific Lab., N. Mex.). July 1967. Contract W-7405-eng-36. 5p. Dep. CFSTI.

Thirty references published since 1960 which include books, reports, and journal articles on Monte Carlo methods (especially in conjunction with hybrid computers) used for the solution of heat transfer problems are given. References are arranged alphabetically by first author. (F.S.)

2297 (ORNL-TM-2029) INVESTIGATION OF ONE CONCEPT OF A THERMAL SHIELD FOR THE ROOM HOUSING A MOLTEN-SALT BREEDER REACTOR. Crowley, W. K.; Rose, J. R. (Oak Ridge National Lab., Tenn.). Nov. 1967. Contract W-7405-eng-26. 63p. Dep. CFSTI.

The concrete providing the biological shield for a 250-MW(e) molten-salt breeder reactor must be protected from the gamma current within the reactor room. A configuration of a laminated shielding wall proposed for the reactor room was studied to determine (1) its ability to maintain the bulk temperature of the concrete and the maximum temperature differential at levels below the allowable maximums, (2) whether or not the conduction loss from the reactor room will be kept below a given maximum value, (3) whether air is an acceptable medium for cooling the wall, and (4) the length of time that a loss of this coolant air flow can be sustained before the bulk temperature of the concrete exceeds the maximum allowable temperature. Equations were developed to study the heat transfer and shielding properties of the proposed reactor room wall for various combinations of lamination thicknesses. The proposed configuration is acceptable for (1) an incident monoenergetic (1 Mev) gamma current of 1×10^{12} photons/cm^2 · sec and (2) an insulation thickness of 5 in. or more. The best results are obtained when most of the gamma-shield steel is placed on the reactor side of the cooling channel. (auth)

2298 (RISO-50) ON THE RELATION BETWEEN EULERIAN AND LAGRANGIAN AVERAGES IN THE STATISTICAL THEORY OF TURBULENCE. Kofoed-Hansen, O.; Wandel, C. F. (Danish Atomic Energy Commission, Risoe. Research Establishment). June 1967. 52p. Dep.

Two important types of probing of a turbulent velocity field u(r,t) are the Eulerian probings defined by dr/dt = v(v constant) and the Lagrangian probing defined by dr/dt = u(r,t). In the case of fully developed isotropic and homogeneous turbulence, explicit expressions in terms of the energy spectrum are derived for the autocorrelation coefficients and power spectra obtained by Eulerian and Lagrangian probing. The derivations given in detail are based on a statistical representation of the turbulent velocity field using the results of the equilibrium theory of turbulence. The Tailor hypothesis is verified in the limit of high probing velocities. The Hay-Pasquill conjecture relating the Lagrangian and Eulerian power spectra is obtained as an approximation to the transformation equations. Application of the results to the theory of turbulent diffusion is indicated. (auth)

2299 (SC-RR-67-232) REENTRY TEMPERATURES OF LOW HEAT CAPACITY STRUCTURES. Klett, Robert D. (Sandia Corp., Albuquerque, N. Mex.). Aug. 1967. 143p. Dep. CFSTI.

Equations are derived for computing the temperatures of low heat capacity structures during reentry for free molecule and continuum flow. These equations were solved for altitudes from 0 to 700,000 feet, velocities from 600 to 38,000 fps, initial temperatures from 500 to 1500°R, and for all expected values of dimensionless groups, which include thermal emissivities and heating ratios. The results are presented in graphical form. The uses and limitations of these graphs for analyzing reentering structures are discussed. (auth)

2300 DRYING CAPACITY OF A GAS IN CLOSED CYCLE. Maroto, J. (Junta de Energia Nuclear, Madrid). Energ. Nucl. (Madrid), 11: 145-8(Mar.-Apr. 1967). (In Spanish).

In order to study the effect of different variables on the humidity obtainable and the drying time, the problem is put in general terms of an equation relating these variables. The variables considered are water input, the time of flight across the enclosure, the recirculation flux of the gas in the drying system, the humidity of the air at the operating temperature, the relative humidity of the ambient air, the relative humidity of the air in the enclosure, the absolute humidity of the gas, and the volume to be dried. The simplifying assumptions made in the derivation of the equation are outlined. The equation is applied to the specific case of the drying of mixtures of U_3O_8 and aluminum powder before compression. (J.S.R.)

2301 SOLUTION OF SOME BOUNDARY PROBLEMS OF HEAT CONDUCTION FOR CYLINDRICAL BODIES PROVIDED WITH LONGITUDINAL FINS. Schmid, J. Nuclear Research Inst., Czechoslovak Academy of Sciences, Rez). Int. J. Heat Mass Transfer, 10: 1305-26(Oct. 1967).

A solution is presented of the temperature field in cylindrical bodies consisting of several annuli provided with external or internal longitudinal fins in the shape of annular sectors or prisms. The problem is analyzed for boundary conditions varying along the periphery, and for an arbitrary distribution of sources over the cross section. Problems of this type are encountered in thermal-engineering computations of longitudinally finned nuclear reactor fuel elements or of longitudinally finned tubes of heat exchangers. The method evolved can also be applied to problems concerning laminar flow in non-circular channels. (auth) (UK)

2302 DESTRUCTION OF PIPES BY HIGH-FREQUENCY PRESSURE OSCILLATIONS DURING HEAT TRANSFER. Kafengauz, N. L.; Fedorov, M. I. At. Energ. (USSR), 23: 147-8(1967). (In Russian).

Heat transfer in surface boiling liquids flowing in pipes at subcritical pressures or at supercritical pressures under pseudo boiling conditions is usually accompanied by pressure oscillations with a frequency between 3000 and 15000 Hz and an amplitude ranging from 2 to 40 kg/cm^2. Examination of this problem for the case of di-isopropylcyclohexane revealed that 10 to 15 minutes after the start of operation the steel pipe was destroyed. This could not be ascribed to a worsening of the heat transfer because in no case did the temperature exceed 750°C and a static pressure remained at 60 kg/cm^2. The 10,000 Hz oscillations subjected the pipe to 6×10^8 cycles during the 10 minutes, resulting in fatigue cracking of the walls. These results show that under the above experimental conditions the fatigue strength of the pipe must be taken into account. (TTT)

2303 BOILING HEAT CONDUCTION ON THE UNWETTABLE SURFACE. Torikai, Kinichi; Yamazaki, Toshi (Japan Atomic Energy Research Inst., Tokyo). Nippon Kikai Gakkai Rombunshu, 32: 1557-61(Oct. 1966). (In Japanese).

Heat conduction at unwettable surfaces is mainly by natural-convection involving bubbles generated and then detached. Burnout does not occur when the detached bubbles prevent the flow of liquid toward the conductive surface, but when the conduction is prevented by the adherence of bubbles onto the conductive surface. It is found that the boiling conduction at unwettable surfaces differs from that of surfaces, and is in a state similar to transition boiling. Consequently, it is possible that high-load conduction at wet surfaces affects the heat conduction through the thin film of bubble-adhered surfaces. (NSA of Japan)

2304 EVAPORATION AND BUBBLES. Ledinegg, M. (Technische Hochschule, Vienna). Atomkernenergie, 12: 428-32(1967). (In German).

Experimental results of South African and German work on evaporation and bubbles are reported. Different results are obtained; the former find that during the process of evaporation the product between volume at departure and frequency of the steam bubbles remains constant while the latter find the same for the product between diameter and frequency. This contradiction is explained in that depending on the nucleation site concentration either the one or the other correlation applies. Static considerations in which the lifting and compressive forces are compared to the adhesive forces permit the determination of the largest possible radius at departure. In reality a radius between zero and the largest possible one which is determined by heat transfer calculations in Japanese experimental work is used as the basis. (tr-auth)

Isotope Technology

Refer also to abstracts 2092, 2263, 2364, and 3179.

2305 (BNWL-SA-1309) $^{147}Pm_2O_3$: PROCESSING AND APPLICATION. Baker, R. J. (Battelle-Northwest, Richland,

Wash. Pacific Northwest Lab.). Sept. 15, 1967. Contract AT(45-1)-1830. 14p. (CONF-670950-1). Dep. CFSTI.

From Nuclear Division Fall Meeting, Urbana, Ill.

Aspects of $^{147}Pm_2O_3$ heat sources which are being considered in aerospace and terrestrial application are discussed, including the characteristics of promethium, Pm_2O_3 forming processes, and current applications. A 60 W heat source is described. (F.S.)

2306 (DP-1129-1) SAVANNAH RIVER LABORATORY ISOTOPIC POWER AND HEAT SOURCES. PART I. ^{60}Co. Quarterly Progress Report, July-September 1967. Hilborn, H. S. (comp.) (Du Pont de Nemours (E. I.) and Co., Aiken, S. C. Savannah River Lab.). Oct. 1967. Contract AT(07-2)-1. 10p. Dep. CFSTI.

Data on the design, fabrication and operation of ^{60}Co heat sources are presented. Estimated production costs for large quantities of ^{60}Co range from about 10¢/Ci at 100 Ci/g to 20¢/Ci at 400 Ci/g. Diffusion of ^{60}Co along grain boundaries may result in concentrations greater than 10^{-8} of the interface concentration at a depth of 0.060 inch in TD Nickel but <0.020 inch in several other alloys after one year at 800°C. Preliminary examination of the Inconel 600 capsule containing radioactive cobalt that was heated in air at ~850°C for 1000 hr indicates that this capsule will be suitable for long-term service. (auth)

2307 (MLM-1416(DEL-1)) SUBCRITICAL NEUTRON MULTRIPLICATION EXPERIMENT WITH SNAP-19C-2 HEAT SOURCES CONTAINING ^{238}Pu ISOTOPE. Wolfe, R. A.; Edling, D. A. (Mound Lab., Miamisburg, Ohio). Mar. 23, 1967. Contract AT(33-1)-Gen-53. 12p. Dep. CFSTI.

Subcritical neutron multiplication determinations with seven SNAP 19C-2 heat sources containing plutonium-238 were performed at different array spacings in both an air and a water medium. The maximum neutron multiplication of 1.14 was obtained with seven SNAP 19C-2 heat sources completely water reflected in a $^1/_{16}$-inch edge-to-edge planar array. The results from this experiment will provide information concerning the nuclear hazards associated with the future design of larger and more powerful heat sources containing plutonium-238. (auth)

2308 (MLM-1419) STABLE GASEOUS ISOTOPE SEPARATION AND PURIFICATION: APRIL-JUNE 1967. (Mound Lab., Miamisburg, Ohio). June 30, 1967. Contract AT(33-1)-Gen-53. 48p. Dep. CFSTI.

Research progress is reported on: carbon isotope separation by thermal diffusion; separation of helium, neon, argon, krypton, and xenon isotopes; molecular beam scattering; transport properties; transport coefficients of neon, krypton, and helium; and low-temperature research. (M.C.G.)

2309 (MMM-3691-23) SNAP-21 PROGRAM, PHASE II. DEEP SEA RADIOISOTOPE-FUELED THERMOELECTRIC GENERATOR POWER SUPPLY SYSTEM. Quarterly Report No. 5, July 1, 1967-September 30, 1967. Fox, F. (Minnesota Mining and Mfg. Co., St. Paul. Isotope Power Lab.). Oct. 1967. Contract AT(30-1)-3691. 198p. Dep. CFSTI.

SYSTEMS FOR NUCLEAR AUXILIARY POWER (SNAP-21) — power supply system for, design and testing of
HEAT SOURCES — development of 10 W strontium-90, for SNAP-21
FUEL CAPSULES — design, fabrication, and testing of SNAP-21
SHIELDING — design of biological, for SNAP-21
THERMAL INSULATION — development and fabrication of SNAP-21
PRESSURE VESSELS — design and testing of SNAP-21
STRESS — calculation of SNAP-21 pressure vessel
HEAT TRANSFER — analysis of SNAP-21 system
THERMOELECTRIC CELLS — components for SNAP-21, design and testing of
URANIUM ALLOYS AND SYSTEMS — Mo-U, tensile properties of, for SNAP-21 biological shield
MOLYBDENIUM ALLOYS AND SYSTEMS — Mo-U, tensile properties of, for SNAP-21 biological shield
THERMOCOUPLES — development and testing of, for SNAP-21 thermoelectric generator
SYSTEMS FOR NUCLEAR AUXILIARY POWER (SNAP-21) thermoelectric generator for, shock testing of (R.C.K.)

2310 (NP-17098) REPORT ON THE INTERNATIONAL COMPARISON OF DILUTION AND SOURCE PREPARATION METHODS BY MEANS OF ^{60}Co. PART 1. RESULTS OF THE INDIVIDUAL LABORATORIES. Mueller, J. W.; Rytz, A. (Bureau International des Poids et Mesures, Sevres (France)). Sept. 1967. 52p. Dep.

The relevant data concerning the counting equipment, source preparation and dilution techniques, etc., used by each of the 25 laboratories are given in a number of tables and figures. The evaluation of the corrections needed as well as the estimation of the errors involved are illustrated by example. Finally, a full account of all experimental results submitted by the laboratories is given, mainly in graphical form. A preliminary analysis of the corrected results, which takes into account the known correlation between the two specific activities, as given by their ratio CR, indicates that the true values for the specific activities of the strong and the weak solutions will lie approximately within the limits: $Q_s \cong (2.893 \pm 2)\ s^{-1}\ mg^{-1}$ and $R_w \cong (136.0 \pm 0.1)\ s^{-1}\ mg^{-1}$, respectively. (auth)

2311 (ORNL-IIC-10(Vol.1)) PROCEEDINGS OF 2ND SYMPOSIUM ON LOW-ENERGY X- AND GAMMA SOURCES AND APPLICATIONS HELD AT UNIVERSITY OF TEXAS, AUSTIN, TEXAS, MARCH 27-29, 1967. Baker, Philip S.; Gerrard, Martha (eds.) (Oak Ridge National Lab., Tenn.). Sept. 1967. 521p. (CONF-670321-(Vol.1)). Dep. CFSTI.

Separate abstracts were prepared for 25 of the 27 papers presented. One paper was previously included in NSA as 21: 28346. One paper was in summary form only and was not abstracted. (B.G.D.)

For abstracts of individual papers see: 1957-1960, 2031, 2176, 2312, 2344-2348, 2396-2401, 2453, 2480, 2521, and 3170-3173.

2312 (ORNL-IIC-10(Vol.1), pp 1-17) REVIEW OF LOW-ENERGY-SOURCE APPLICATIONS. Hitch, James W. (Division of Isotopes Development (AEC), Washington, D. C.).

Future improvements in instrumentation are predicted which provide greater capability for meeting the ever-increasing requirements in the fields of crime detection, space and terrestrial exploration, environmental pollution analysis, and industrial quality control. A review of the development and evaluation of low-energy radiation sources to meet these needs is presented. (auth)

2313 CALCULATIONS OF PENETRATION FACTORS OF SLIT SHAPED COLLIMATORS AND CYLINDRICAL GAMMA-SOURCES WITH SELF-ABSORPTION. Knoth, J.; Sandrock, F.; Schwenke, H. (Kernenergieverwertung in Schiffbau und Schiffahrt mbH, Geesthacht, Ger.). Atomkernenergie, 12: 425-7(1967). (In German).

Self-absorption factors of a cylindrical γ-source in front of a slit shaped collimator are calculated taking into account the penetration of radiation through the edges of the collimator. The calculations are made for various attenuation coefficients of the cylinder as well as the collimator material, and for different slit widths, collimator lengths and diameters of the source. Moreover the aperture of a real collimator is defined and computed which is of particular interest in connection with the gamma-scanning method. (auth)

2314 BUILDUP FACTORS FOR POINT ISOTROPIC GAMMA-RAY SOURCES IN INFINITE MEDIUM OF ORDINARY CONCRETE. Chilton, A. B. (Univ. of Illinois, Urbana). Nucl. Eng. Design, 6: 205-12(1967).

In order to provide more definitive values for buildup factors for point, isotropic gamma ray sources in an infinite medium of ordinary concrete, a Monte Carlo program has been undertaken to make such calculations. Previous approaches to this problem had been through the assumption of a Z_{eff} for concrete and in interpolation in the existing Goldstein-Wilkins results for single elements. In addition to the approximate character of the old procedure, such calculations have been variable because different values of Z_{eff} have have been used by different workers. The specific method of Monte Carlo calculation is briefly described, with emphasis on the assumptions, approximations, and sources of data. The resulting data are estimated to have an uncertainty less than 5%. They are compared with results using the Z_{eff} approach, and the asymptotic trends at very small and very large penetration distances are discussed. (auth)

2315 RADIOISOTOPES IN INDUSTRY CONFERENCE, UNIVERSITY OF SOUTHAMPTON, ENGLAND, APRIL 21, 1966. Southampton, Eng., University of Southampton, 1966. 19p. (CONF-660460). DTIE.

The fundamentals of radioisotopes and their uses in industry for quality control, nondestructive testing, flow measurements, radiography, and for powering thermoelectric generators are discussed. Radiological safety and legal requirements for handling radioisotopes are pointed out. The availability of the Isotope Research Division of the U. K. Atomic Energy Authority for assistance in developing industrial applications of radioisotopes is mentioned. (L.C.L.)

Materials Testing

Refer also to abstracts 2271, 2607, and 2610.

2316 (IITRI-578P21-22) STUDIES OF REACTOR CONTAINMENT. VOLUME II. DETERMINATION OF THE EQUATION-OF-STATE OF POROUS SOLIDS. Task Two Final Report. Lieberman, Paul (IIT Research Inst., Chicago, Ill.). Oct. 1967. Contract AT(11-1)-578. 105p. Dep. CFSTI.

A helium/air shock tube is designed to give controlled blast waveforms for impingement against a porous solid contained in a special specimen holder. The sensors in the specimen holder are arranged to detect elastic wavefront, plastic wavefront, reflected plastic wavefront, unloading wavefront, particle velocities in the crushing solid, and gas pressure in the impingement gases. The data records are interpreted in terms of a wave diagram from the pressure-time histories at several stations along the specimen holder. The wave diagrams for several blast impingement pressures are combined to construct the equation-of-state of the porous solid in loading and in unloading. The stress-volume relations in shock loading, isentropic unloading and shock reloading for Celotex, styrofoam, redwood, sugar pine, foamglass and balsa were obtained at normal stresses of 300 to 17,000 psi. Wall friction effects and Malvern-type strain-rate sensitivity effects are considered. The choosing of materials and the designing of blast shields in connection with reactor containment are discussed. (auth)

2317 (TID-24106) PHOTOELASTIC DETERMINATION OF STRESSES AT AN OPENING IN A THIN-WALLED CYLINDRICAL PRESSURE VESSEL. Leven, M. M. (Westinghouse Research Labs., Pittsburgh, Pa.). Aug. 24, 1967. Contract W-7405-eng-26; Subcontract 2916. 33p. Dep. CFSTI.

For Oak Ridge National Lab., Tenn.

The distribution of the principal stresses on the inner and outer surfaces in the vicinity of an opening in a thin-walled cylindrical vessel subjected to internal pressure were obtained photoelastically. The ratio of the diameter of the opening to that of the vessel, d_i/D_i, was 0.129, while the ratio of the diameter to thickness of the vessel, D_i/T, was 99.1. The ratio of nominal stresses in the opening and the vessel, s/S, was 0.93. Principal stress distributions along the inner and outer surfaces were obtained for the 0° (longitudinal), 15°, 30°, 45°, 60°, 75° and 90° (transverse) sections. The maximum stresses occurred on the longitudinal section: At the fillet on the outer surface and near the corner on the inner surface. At the exterior fillet the maximum circumferential stress was 4.75 S while the peak meridian stress was found to be 3.67 S. At the inner corner the maximum circumferential stress was 3.61 S. These maximum values compared favorably with those obtained analytically by Eringen, empirically (area replacement) by Lind and others, and experimentally by Rose. (auth)

2318 ULTRASONIC IMAGING LAMB-WAVE SYSTEM FOR REACTOR-FUEL-PLATE INSPECTION. Berger, H. Ultrasonics, 5: 39-41(Jan. 1967).

A television continuous-wave ultrasonic system for inspection of flat nuclear reactor fuel elements is illustrated and described. The television system incorporates an electron multiplier within the camera tube. In the through-transmission no-ultrasonic lens system, object area as large as 9.5 cm in diam can be observed. Unbonded areas and variations in homogeneity, inclusions and similar discontinuities are readily observed. Examples of defect images are shown. The system offers superior speed and improved resolution over mechanical scan-through transmission techniques. A combined inspection system is recommended including preliminary 100% inspection by television system, utilizing its speed, resolution and sensitivity to defects, followed by mechanical-scan ultrasonic inspection, utilizing its defect differentiation ability. (Rev. Met. Lit.)

2319 NONDESTRUCTIVE MATERIAL TESTING IN THE PRODUCTION OF FUEL ELEMENTS. Becker, E. Wiss. Z. Tech. Hochsch. Otto Guericke Magdeburg, No. 1-2, 107-16(1966). (In German).

Methods of nondestructive testing used in the testing of nuclear fuel assemblies are reviewed. The following procedures are surveyed: measured of cladding thickness (autoradiography, absorption of beta radiation, standard radiography, ultrasonic resonance methods, magnetic induction), material defect detection (ultrasonic pulse-echo procedures, eddy-current testing, replicas), permeability (gas detection methods), welds (He penetration and radiography), position of the fuel within the cladding (radiography), defects in the fuel structure (eddy current, autoradiography), grain size and homogeneity (ultrasonic velocity and extinction measurements, x-ray techniques), U content (scintillation spectrometry) and the bond between the cladding and the fuel (frost test method, ultrasonics, fluorescence, thermography). (Rev. Met. Lit.)

Radioactive Material Handling

Refer also to abstracts 2273 and 2468.

2320 (BNWL-464) PLUTONIUM LABORATORY DECONTAMINATION EXPERIENCE. Bardsley, R. E.; Merker, L. G. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Sept. 1967. Contract AT(45-1)-1830. 24p. Dep. CFSTI.

Detailed procedures and special decontamination efforts used in decontaminating the Plutonium Fuel Laboratory which resulted from the spread of UO_2-PuO_2 materials released during an explosion and fire in a glove box on August 23, 1965 are discussed. Airborne contamination reached 2×10^{-8} $\mu Ci/cm^3$ in certain areas and the surface contamination was as high as 200,000 dis/min/100 cm^2. Decontamination was completed 4 months after the explosion. The respiratory protection and protective clothing which were used are shown. Procedures for decontamination or removal for burial of equipment such as filters and tools and structural materials such as floor tiles and wall coatings are described. (F.S.)

2321 (GAMD-7979) HTGR SPENT-FUEL SHIPPING COSTS. Seden, W. H. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). Aug. 17, 1967. Contract AT-(04-3)-167. 29p. Dep. CFSTI.

Costs were estimated for shipping spent fuel elements from a 1000 MW(e) HTGR plant to a reprocessing plant located 1000 miles away. The fuel was assumed to be shipped in one of four different size casks (49-, 21-, 7-, or 3-element capacity). The 49- and 21-element capacity casks can be transported only by rail because of the large weights involved. The 7- and 3-element capacity casks can be transported by rail or truck. The lowest cost of shipping the spent fuel is realized by shipping the fuel in the 49-element capacity cast (~$22 per kilogram of heavy metals). The highest cost is realized by shipping the fuel in the 7-element capacity cask by truck (~$85 per kilogram of heavy metals). The cost of shipping the fuel by truck is less than by rail only if shipments are limited to the 3-element capacity cask. The shipping costs for this cask are $71 by truck, and $78 by rail per kilogram of heavy metals. These figures do not include costs of shipping reflector elements. (auth)

2322 (IN-1119) MANUAL OF PROCEDURES FOR EFFECTING CONTROL OF SS MATERIALS AT STATION JWA. Tingey, F. H.; Lewis, B. S. (Idaho Nuclear Corp., Idaho Falls). Oct. 1967. Contract AT(10-1)-1230. 88p. Dep. CFSTI.

Basic principles and techniques to maintain adequate surveillance and control of all SS materials at the Idaho Chemical Processing Plant (ICPP) are outlined. Material control aspects cover the entire process facility in addition to the fuel storage basin, waste storage facilities, auxiliary plants, and research and chemical analysis laboratories. (F.S.)

2323 (ORNL-TM-1887) WASTE TREATMENT AND DISPOSAL SEMIANNUAL PROGRESS REPORT, JULY-DECEMBER 1966. Blanco, R. E.; Parker, F. L. (Oak Ridge National Lab., Tenn.). Contract W-7405-eng-26. 139p. Dep. CFSTI.

The objective of the program is to develop and demonstrate, on a pilot plant scale, integrated processes for the treatment and the ultimate disposal of radioactive wastes resulting from reactor operations and reactor fuel processing. The wastes include those containing high, intermediate, and low levels of radioactivity in liquid, solid, or gaseous forms. Under the integrated plan, low-activity wastes that consist of very dilute salt solutions, such as cooling water and canal water, are treated by scavenging and ion exchange processes or foam separation to remove radioactive constituents; then the water is discharged to the environment, or recycled and reused. The retained waste solids or slurries are combined with the high-activity wastes or incorporated into asphalt or concrete before disposal in concrete vaults, salt mines, or burial pits. Alternatively, the retained solids or the untreated waste is discharged to the environment in deep geologic formations. The high-activity wastes are alternatively stored at their sites of origin for desired periods to allow for radioactive decay and artificial cooling. Methods investigated for the permanent disposal of high-activity liquid wastes include conversion to solids by high-temperature pot calcination or glass formation in the final storage container (pot) and formation of a glass or ceramic in a continuous melter. Tank storage or high-temperature calcination of intermediate-level wastes may be unattractive because of the large volumes involved, and thus other disposal methods will be studied. One of these, the addition of solidifying agents prior to direct disposal into impermeable shale by hydrofracturing, has been investigated. Particular attention was given to the engineering design and construction of an experimental fracturing plant to dispose of ORNL intermediate-level wastes by this method. A second method is incorporation (and dehydration) of intermediate-level wastes in asphalt. Environmental research on the Clinch River, motivated by the need for safe and realistic permissible limits of waste releases, is included in this program. The objective is to obtain a detailed characterization of fission product distribution, transport, and accumulation in the physical, chemical, and biological segments of the environment. (J.R.D.)

2324 (RFP–1025) CRITICAL MASSES OF SPHERICAL AND HEMISPHERICAL STEEL-MODERATED, OIL-REFLECTED ENRICHED URANIUM ASSEMBLIES. Ernst, Bruce B.; Tuck, Grover (Dow Chemical Co., Golden, Colo. Rocky Flats Div.). Nov. 6, 1967. Contract AT(29-1)-1106. 8p. Dep. CFSTI.

Critical masses were experimentally determined for steel-moderated, oil-reflected, spherical and hemispherical enriched uranium assemblies having inside radii from 0.0 to 12.0 cm. (auth)

2325 (RISO–150) PILOT-PLANT VITRIFICATION OF SIMULATED RADIOACTIVE WASTE WITH HEAT PRODUCED BY SENDING ALTERNATING CURRENT THROUGH THE GLASS. Brodersen, Knud; Larsen, Ib (Danish Atomic Energy Commission, Risoe. Research Establishment). May 1967. 47p. Dep.

The principle of heat production by sending alternating current through molten glass is demonstrated in the vitrification of a simulated medium-active waste. Two different pilot-plant procedures are tried out. The first is a discontinuous method. The melting takes place in a stainless-steel cylinder, which is then used as a permanent storage container. The second method is continuous. The melting takes place in a permanent ceramic chamber encased in a metallic container to ensure air tightness and mechanical strength. The glass is removed continuously through an overflow system and collected in cylinders of ordinary steel. Corrosion of the stainless-steel electrodes is no problem, but the corrosion of the ceramic material is somewhat too serious for practical long-term use at the present state of the development. (DENM)

2326 (JPRS–42565) DISPOSAL OF RADIOACTIVE WASTE. Translation of Eight Papers Presented at the International Atomic Energy Agency Symposium on Disposal of Radioactive Waste in the Ground, Vienna, May 29–June 2, 1967. 109p. (TT–67-33193). CFSTI.

Eight papers on Russian studies of the underground disposal of radioactive wastes are presented. Separate abstracts were prepared for each. (L.C.L.)

For abstracts of individual papers see: 2327–2334.

2327 (JPRS–42565, pp 1-11) EXPERIMENTAL BURIAL OF RADIOACTIVE WASTES OF LOW ACTIVITY LEVEL IN CLAY SOILS AT MOSCOW STATION. Sobolev, I. A.; Khomchik, L. M.; (and others). Translated from International Atomic Energy Agency Symposium on Disposal of Radioactive Waste in the Ground, Vienna, May 29–June 2, 1967. (CONF-670512–6).

The burial of low-level radioactive wastes in clay soils near the Moscow Radioactive Waste Disposal Station was investigated. The soil was analyzed for geological make-up and for adsorption properties. The composition of the wastes was determined. Experimental burials were made and their effects tested after one year. It was determined that the clay soils of this area have a rather high capacity for adsorption of ^{137}Cs and ^{90}Sr, that this adsorption occurs during the process of infiltration through the soil, and that the rate of movement of activity into the soils for both liquid and cemented solid wastes amounts to between 0.3 and 1.0 meters per year. The soil at this burial site was concluded to be unusable for the burial of radioactive wastes. (L.C.L.)

2328 (JPRS-42565, pp 12-22) INVESTIGATION OF SORPTION AND MIGRATION OF RADIOACTIVE ISOTOPES IN SOILS AND ROCKS OF VARIOUS COMPOSITIONS. Spitsin, V. I.; Balukova, V. D. Translated from International Atomic Energy Agency Symposium on Disposal of Radioactive Waste in the Ground, Vienna, May 29–June 2, 1967. (CONF-670512-7).

The use of soils for the natural purification of liquid radioactive wastes was investigated. Laboratory tests were performed to study the distribution, migration, and sorption of radioisotopes from liquids filtered through various types of soils. Field experiments were conducted to determine the migration of ^{90}Sr from solutions dumped into upper soil layers located over water bearing strata. It was concluded that dumping liquid radioactive wastes into such soils is a public health hazard, that the most even distribution of radioisotopes with the least amount of contaminated soil occurs in porous water bearing horizons, and that use of such horizons for waste disposal requires low rate of movement of the stratal water, reliable waterproofing of horizon top and bottom, and a soil area of no economic value. (L.C.L.)

2329 (JPRS–42565, pp 23-35) STUDY OF CONDITIONS FOR BURIAL OF RADIOACTIVE CEMENT IN SOILS. Bazhenov, Yu. M.; (and others). Translated from International Atomic Energy Agency Symposium on Disposal of Radioactive Waste in the Ground, Vienna, May 29–June 2, 1967. (CONF-670512–8).

Conditions affecting the burial of concrete-solidified radioactive wastes were investigated. The effects of the soil and ground water on the release of radioisotopes from the waste were studied. It was concluded that due to leaching of radioisotopes, only concrete blocks with an activity of less than 10^{-6} Ci/l with respect to ^{137}Cs and ^{90}Sr can be stored safely without hermetic sealing and waterproofing, that concrete blocks with activities of 10^{-5} Ci/l or less can be stored safely under a loam covering, and that the quantity of gaseous radiolysis products liberated during the storage of concrete solidified waste depends on the specific activity of the concrete block, the storage time, air space volume in the vessel, and the volume and geometry of the blocks. (L.C.L.)

2330 (JPRS–42565, pp 36-55) PROBLEM OF HEAT GENERATION IN UNDERGROUND STORAGE OF SOLID RADIOACTIVE WASTES. Verigin, N. N.; Zimakov, P. V.; (and others). Translated from International Atomic Energy Agency Symposium on Disposal of Radioactive Waste in the Ground, Vienna, May 29–June 2, 1967. (CONF-670512–9).

Heat generation in the underground storage of radioactive wastes was investigated first, theoretically, by calculated for the heat sources and the soils in which the wastes would be buried, and then, empirically, by placing electrically heated sources in soils and measuring the heat produced. The soil types investigated were mainly sand and clay, plus limestone, shale, granite, sandstone, and basalt. The types of solidified waste included bituminized, vitrified, and basalt. The results are stated in terms of permissible storage area required for the specific activities of the solid wastes. The general conclusion is that more effective utilization of burial areas can be achieved by providing for heat removal. (L.C.L.)

2331 (JPRS–42565, pp 56-66) POSSIBILITY AND EXPEDIENCY OF MELTING CALCINATED RADIOACTIVE WASTES IN THE GROUND. Verezhgunov, V. G.; Zakharova, K. P.; (and others). Translated from International Atomic Energy Agency Symposium on Disposal of Radioactive Waste in the Ground, Vienna, May 29–June 2, 1967. (CONF-670512–10).

A chemothermic method for melting calcinated radioactive waste underground was investigated. Factors considered were the thermite additive required, the heat produced in the melted material and the surrounding soils, the effect of soil type, the production of gases during the process, the nature of the residual waste, and the size and shape of burial sites required. Further experiments are recommended. (L.C.L.)

2332 (JPRS–42565, pp 67-81) SCIENTIFIC PREMISES FOR THE USAGE OF DEEP FORMATIONS FOR STORAGE OF LIQUID RADIOACTIVE WASTES. Spitsin, V. I.; (and others). Translated from International Atomic Energy Agency Symposium on Disposal of Radioactive Waste in the Ground, Vienna, May 29–June 2, 1967. (CONF-670512–11).

An investigatigation was made of the possibility of using deep geological formations for storing liquid radioactive wastes. A review is given of the geophysical, geological, and hydrological factors which affect the safe storage of liquid radioactive wastes underground. One area of Russia was examined and was considered suitable for beginning experimental disposal of liquid wastes in the third permeable zone. (L.C.L.)

2333 (JPRS–42565, pp 82-96) SOME RESULTS OF OPERATION OF PILOT SCALE INSTALLATION FOR DISPOSAL OF LIQUID RADIOACTIVE WASTES IN DEEP FORMATIONS OF EARTH'S CRUST. Zakharov, S. I.; (and others). Translated from International Atomic Energy Agency Symposium on Disposal of Radioactive Waste in the Ground, Vienna, May 29–June 2, 1967. (CONF-670512–12).

The disposal of liquid radioactive wastes in deep formations of the earth's crust was studied using an industrial scale model installation. The equipment and method used provided failure-free operation of the system. The results indicate that the waste preparation system allows production of wastes which are compatible with natural waters and rocks of the strata. The capacity of the feed borehole after the startup and adjustment period was found to be 1.1 to 1.2 m^3/day per meter of excess pressure. It is concluded that the disposal of decontaminated water in deep formations can be performed on an industrial scale where the hydrogeological conditions are favorable and that this method has economic advantages over the evaporation of wastes. (L.C.L.)

2334 (JPRS–42565, pp 97-109) THE CENTRAL STORAGE AREA FOR RADIOACTIVE WASTES IN THE CZECHOSLOVAKIAN SSR. Golub, I.; Kortus, I.; Zayits, I. Translated from International Atomic Energy Agency Symposium on Disposal of Radioactive Waste in the Ground, Vienna, May 29–June 2, 1967. (CONF-670512–13).

A central underground area for the storage of radioactive wastes was constructed in Czechoslovakia because no natural geologic formations suitable for this purpose exist. Details are given on the problems of site location, actual construction,

methods of containing and handling the radioactive wastes, and the capacity and cost of the storage area. (L.C.L.)

2335 UNDERGROUND DISPOSAL OF ^{85}Kr FROM NUCLEAR FUEL REPROCESSING PLANTS. Tadmor, Jacob; Cowser, K. E. (Oak Ridge National Lab., Tenn.). Nucl. Eng. Design, 6: 243-50(1967).

An evaluation was made of the different methods for large-scale removal of ^{85}Kr from the off-gas stream of a reprocessing plant and of the feasibility of underground disposal of ^{85}Kr. Although the apparent advantages of underground disposal are its relative simplicity and effectiveness, one severe requirement is that the disposal formation must be essentially free of vertical channels. The principal mechanisms by which ^{85}Kr may be retarded or retained underground include adsorption and trapping (containment). In the absence of convective transport, vertical underground movement is influenced by molecular diffusion. These mechanisms are evaluated for quantities of ^{85}Kr and volumes of off-gas assumed to be produced at a 10 tons/day reprocessing plant. (auth)

2336 AN ARRANGEMENT FOR INSERTING, HOLDING, AND SEALING EXCHANGEABLE FILTERS INTO DISCHARGE DUCTS FOR POLLUTED AIR. Benzel, Martin; Bremen, Folker; Braun, Franz (to H. Krantz Verwaltungs GmbH). British Patent 1,089,730. Nov. 8, 1967. Priority date Oct. 8, 1965, Germany.

The equipment is described and is particularly suited for air ducts carrying radioactive dust. The filter element which has a rigid rectangular frame with a sealing gasket bonded to the frame is inserted through a closable opening in the duct by toggle levers, and the sealing gasket is pressed to a sealing flange located inside the duct. (F.S.)

2337 MASTER-SLAVE MANIPULATOR WITH ARTICULATED ARMS. Vertut, Jean (to Commissariat a l'Energie Atomique). British Patent 1,089,399. Nov. 1, 1967. Priority date Nov. 15, 1963, France.

A master-slave manipulator which penetrates into a hot cell through a lateral wall and is provided with at least 2 articulated arms at the end of a horizontal through-tube is described. The articulated arms do not provide telescopic movement but provision is made for relative displacement of the master arm and slave arm. The manipulator consists of a member to traverse a passage in a fixed wall and capable of rotation relative to the wall with shoulder pivot means at each end of the traversing member. Each shoulder pivot includes one upper arm articulated by elbow pivot means to a forearm, and a wrist member pivotally articulated to a forearm. The arms can pivot through 2 angles in the same direction as can a control member pivoted to the wrist and a slave follower member pivoted to the wrist member of the sleeve assembly. A means is provided to enable the angle of movement of the slave to be augmented by an auxiliary angle of movement relative to the angle of movement of the master. (F.S.)

2338 LIFTING AN OBJECT CONTAINED IN A BAG. Vogel, Gerhard J.; Carls, Erwin L.; Murphy, William A. (to U. S. Atomic Energy Commission). U. S. Patent 3,358,857. Sept. 19, 1967.

A system for removing contaminated material from a glove box with two hooks, each having a base member is described. One base member is internal and one is external to a bag, which is sealed to a port in the glove box, and the two base members are clamped together by means external to the bag. Contaminated material is attached to the hook internal to the bag and raised through the port; then, the bag is sealed and severed between the port and the contaminated material. (AEC)

Vacuum Engineering

2339 HIGH VACUUM TECHNIQUE. THEORY, PRACTICE, AND PROPERTIES OF MATERIALS. FOURTH EDITION. Yarwood, J. High Vacuum Series. New York, Barnes and Noble, Inc., 1967. 280p. $6.50.

The theory and practice of vacuum science and technology are discussed. Information on vacuum systems, vacuum production and measurement, pump performance, and miscellaneous materials, devices, and processes of interest in vacuum technology is presented. (R.C.K.)

INSTRUMENTATION

Radiation Detection Instruments

General Detectors and Monitors

Refer also to abstracts 2211, 2245, 2256, 2443, 2502, 3663, and 3689.

2340 (ABS-THH-1033) PRAEPARATION DUENNER AKTIVIERUNGSSONDEN FUER NEUTRONENFLUSSMESSUNGEN. (Preparation of Thin Activation Probes for Neutron Flux Measurements). Stiller, G. (Technische Hochschule, Hanover (West Germany). Arbeitsgruppe fuer Bautechnischen Strahlenschutz). Sept. 1966. 14p. (In German). Dep.

The methods investigated for the preparation of thin activation probes for neutron flux measurements were described. The methods considered were vacuum evaporation, drying of solutions, preparation of alloys from probe materials, and precipitation of the oxide of the probe material in plastics. The vacuum evaporation method is not especially suitable for the preparation of probes which must be easy to handle. In the drying method the salt crystallized in relative large crystal block on the surface of the filter paper. Only Pb alloys were investigated and these could be prepared with a maximum weight deviation of ±5%. The foils prepared by precipitation in plastic were very sturdy and easy to handle. (J.S.R.)

2341 (AECL-2764) VARIATION OF THE γ-RAY RESOLUTION OF Ge(Li) DETECTORS WITH THE POSITION OF IRRADIATION. Chartrand, M. G.; Malm, H. L. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). June 1967. 27p. Dep. CFSTI CAN $1.00.

A study was made of the γ-ray energy resolution of planar Ge(Li) p-i-n detectors showing varying degrees of charge trapping. A small area collimated beam of ^{51}Cr (320 keV) γ-rays was used to irradiate the detectors both parallel and perpendicular to the junction surfaces. (For some measurements a ^{137}Cs source (662 keV) was also used.) Three detectors, from different crystals, were studied in detail. To identify the carrier being trapped, the beam was directed parallel to the junctions and was moved from one junction to the other. The three detectors exhibited the best resolution and the maximum pulse height when irradiated adjacent to the n^+-i boundary, indicating predominantly electron trapping. For example, with one detector, the detector contribution to the resolution $(\Delta E)_D$ varied from 1.9 keV at the n^+-i junction to 8.7 keV at the i-p junction (E_γ = 320 keV). Considerable variation of resolution with position was also observed when a 2 mm diameter beam was directed perpendicular to the junction surface. With one detector, (E_γ = 320 keV), $(\Delta E)_D$ varied from 1.7 to 10.7 keV indicating considerable inhomogeneity in the distribution of trapping centers. Counts of the etch pit density made on one detector showed no correlation with the variations in energy resolution. The etch pit density varied over the range 500-4000 cm^2 on this crystal. (auth)

2342 (CEA-R-3189) REDUCTION DE LA DUREE DE L'ETAT D'INSENSIBILITE NATURELLE D'UN COMPTEUR A IONISATION GAZEUSE DE GEOMETRIE 4π TRAVAILLANT EN REGIME DE GEIGER-MUELLER. (Reduction of the Duration of the Natural Dead Time of a 4π Gas Ionization Counter Operating in Geiger-Mueller). Becker, Antoine (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). July 1967. 100p. (In French). Dep.

It is only possible to benefit from the 100 per cent efficiency of a 4π gas-ionization detector operating in the Geiger-Mueller regime (an efficiency which always appears difficult to attain in other detectors) if one is able: on the one hand to reduce considerably and on the other hand to fix very precisely the length of the real dead time of the system operating in the above conditions. Taking into account both the phenomena characteristic of the discharge in the regime under consideration, phenomena whose properties are described, and the geometrical conditions depending on the operation over a solid angle of 4π, it is shown that with an exterior electronic system for cutting off the discharge for example in 30 nanoseconds, absolute 4π GM measurements would become competitive with those now carried out almost exclusively in proportional conditions. Measurement results on sources of 5×10^3 emissions per second maximum obtained by the use of a system for which the interval between the passage of a particle and the moment when the device has been made insensitive is still 60 nanoseconds have made it possible to confirm these statements. (auth)

2343 (JINR-P13-3488) APOKHROMATIZATSIYA I TRIGONOMETRICHESKII RASCHET KHODA LUCHEI V SCHETCHIKAKH CHERENKOVA. (Apochromatization and Trigonometric Calculation of the Ray Path in Cherenkov Counters). Zrelov, V. P.; Paviovic, P.; Sulek, P. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1967. 51p. Russian). Dep.

A method of calculation of an apochromatic system consisting of two axial prisms is considered. Such a system makes it possible to extract Vavilov–Cherenkov radiation with three different wave-lengths under the same chosen angle in differential Cherenkov counters. Formulas are given making it possible to calculate trigonometrically the path of an arbitrary ray of the Vavilov–Cherenkov radiation cone in Cherenkov counters, the optical system of which consists of a radiator, a double axial prism and a spherical mirror. Algorithms for all the computations written in Algol 60 are contained in the appendices. (auth)

2344 (ORNL-IIC-10(Vol.1), pp 248-67) NEW AUTOFLUOROSCOPIC CAMERA. Beierwaltes, William H.; Brown, Gordon M.; Jones, Lawrence W.; Thomas, F. Deaver (Michigan Univ., Ann Arbor. Bendix Corp., Ann Arbor, Mich. Aerospace Systems Div.).

A prototype autofluoroscope camera designed for the visualization of radionuclide distributions in humans is described. This instrument consists of a lead collimator, a 1-in. thick 9-in. diameter sodium iodide scintillation crystal, a fast lens system, an optical image amplifier tube, an optical transfer lens system, a fast photographic recording system, and mechanical means for positioning the camera adjacent to the patient. Collimation is provided by a choice of various interchangeable pinhole or multichannel collimators. The scintillations produced by gamma-ray interactions in a 9″ diameter NaI crystal are viewed by a fast lens system and focused on the image intensifier photocathode. The image amplifier is a cascaded, 3-stage, magnetically focused RCA C70021T. The gain of this tube is such that light produced by a single electron from the photocathode can be imaged through a 1:1 f/0.8 transfer lens and recorded on Polaroid Film. Initial evaluations of this camera system with phantom sources suggest that a resolution of 4-5 mm can be achieved. The primary problem has been a high photocathode noise level which limits the sensitivity of the instrument. Correction of this problem by photocathode cooling is feasible, preliminary studies suggesting a decrease in noise by a factor of 25. (auth)

2345 (ORNL-IIC-10(Vol.1), pp 268-81) RECENT IMPROVEMENTS IN THE SPARK-IMAGING CAMERA. Horwitz, Norman H.; Forsaith, Ann L.; Lofstrom, James E. (William Beaumont Hospital, Royal Oak, Mich.).

When used with photon energies below 100 keV, the spark-imaging camera offers a simple method of mapping radioactive distribution patterns. The instrument is rugged and the associated gear is not complex. The imaging system has been made portable with the development of a battery-powered high-voltage supply and an integrated circuit decade counter. A glow-discharge cleaning procedure eliminates the hot and dead areas in the electrode system and assures uniform sensitivity. The use of a ceramic spacer ring simplifies the construction and allows operation at higher overvoltages. The imaging system was used clinically to obtain high-resolution distribution patterns of radioiodine in the human thyroid gland. Time-lapse imaging of transient distributions were carried out in experimental animals. With doses of 200 microcuries it is possible to obtain a useful image in 30 seconds. (auth)

2346 (ORNL-IIC-10(Vol.1), pp 376-92) THE STABILITY OF X-RAY PROPORTIONAL COUNTERS UNDER EXTREME OPERATING CONDITIONS. Sanford, P. W.; Culhane, J. L. (University Coll., London (England). Mullard Space Science Lab.).

The extreme conditions of high counting rate, high multiplication factor, and high total number of counts are considered. Investigations of the changes in performance occurring under these conditions are reported. The effect of geometry on the saturation properties at high counting rates is discussed and experimental results presented. Data are also presented on the dependence of energy resolution on the total number of counts registered by counters which have methane as a quench gas. The mechanism responsible for this deterioration is described. The multiplication factor influences the behavior both at high counting rates and for high total number of counts. The optimum multiplication factor as a function of x-ray energy is discussed in this connection. (auth)

2347 (ORNL-IIC-10(Vol.1), pp 393-423) COMPARISON OF DETECTORS FOR ISOTOPIC X-RAY ANALYZERS. Burkhalter, Philip G.; Campbell, William J. (Bureau of Mines, College Park, Md.).

Isotopic x-ray analyzers for use as drill-hole probes and process monitors are being developed and evaluated as part of the Bureau of Mines Heavy Metals Program. Optimization of the x-ray detector is required to analyze low-grade gold and silver ores, using energy dispersion techniques coupled with isotopic x-ray excitation. The following properties of gas, scintillation, and semiconductor x-ray detectors are compared: detection efficiency, pulse resolution, intensity linearity, stability, size, ruggedness, and cost. Scintillation detectors have satisfactory overall detection capabilities except for poor pulse resolution. Gas proportional detectors are excellent low energy x-ray detectors except space charge results in pulse shifts with intensity. Semiconductor detectors are attractive because their sharp pulse resolution (less than one keV) allows multi-element determination by electronic pulse analysis. (auth)

2348 (ORNL-IIC-10(Vol.1), pp 503-21) MOBILE X-RAY FLUORESCENCE DETECTOR FOR MINERAL EXPLORATION. Senftle, Frank E.; Tanner, Allan B. (Geological Survey, Washington, D. C.).

An X-ray fluorescence detector using a lithium-drifted silicon diode mounted in a vehicle has been constructed for mineral exploration over relatively flat terrain. Both isotopic and dental X-ray sources are used for excitation. This detector was built primarily to evaluate the field problems (such as scattering, matrix, etc.) in using a continuous X-ray fluorescence method and to determine whether or not such a method has practical utility. Only preliminary tests have been made to date. Scattering is a serious problem which to a great extent is overcome by the high resolution of the solid-state counter. (auth)

2349 (ORNL-TM-2011) ALPHA AIR MONITOR FOR ^{239}Pu. Gupton, E. D. (Oak Ridge National Lab., Tenn.). Sept. 27, 1967. Contract W-7405-eng-26. 15p. Dep. CFSTI.

An Alpha Air Monitor which will reliably detect 8 MPC-hrs of ^{239}Pu in the presence of radon and daughters, in concentrations which vary by factors of more than 100, and in varying, moderate levels of gamma radiation, was developed and field tested at Oak Ridge National Laboratory. Beginning with an experimental device in 1956, more refined models were progressively designed and tested. The latest model has good sensitivity and reliability with uncomplicated design and operational features. The principle of operation is based on the alpha-to-beta particle emission-rate ratio of the collected air sample. (auth)

2350 (UCRL-17818) GERMANIUM FET: A NOVEL LOW-NOISE ACTIVE DEVICE. Elad, Emanuel; Nakamura, Michiyuki (California Univ., Berkeley. Lawrence Radiation Lab.). Sept. 1967. Contract W-7405-eng-48. 17p. (CONF-671026-7). Dep. CFSTI.

From 14th Nuclear Science Symposium, Los Angeles, Calif.

A novel device for low-noise amplification, the germanium junction field-effect transistor (JFET) is introduced. The properties of germanium and silicon at cryogenic temperatures are summarized. Based on the conclusions of this summary, a theoretical comparison between germanium and silicon JFET's is made, followed by a comparison of commercially available JFET's from both materials. A low-noise preamplifier featuring liquid-helium-cooled germanium JFET's was built and operated with semiconductor radiation detectors. Pulse generator resolution of the preamplifier for zero external capacitance is 0.28 keV fwhm (Ge) with a slope of 0.018 keV/pF. Actual resolution obtained with the silicon detector for low-energy x rays is 0.37 keV. (auth)

2351 ON THE AGEING OF SELF-QUENCHING GM COUNTERS. Peeva, A.; Rijhikov, St. (Univ. of Sofia). Nucl. Instrum. Methods, 57: 171-2(Dec. 1967).

On the basis of changes in the gas mixture and electrodes, the ageing of self-quenching GM counters was investigated. The results showed that the anode plays a leading role in the process of ageing, up to the extent of ageing at which the quenching component is still not completely dissociated. (auth)

2352 USE OF ^{133}Ba AS A CALIBRATION STANDARD FOR Ge(Li) DETECTORS. Gurfinkel, Y.; Notea, A. (Soreq Nuclear Research Centre, Yavne, Israel). Nucl. Instrum. Methods, 57: 173-4(Dec. 1967).

The energies and intensities of the gamma and X-rays in the decay of ^{133}Ba were measured. This nucleus is recommended for use as a calibration standard for Ge(Li) detectors. An example is given. (auth)

2353 FABRICATION AND USE OF HIGH RESOLUTION LITHIUM-DRIFTED GERMANIUM GAMMA-RAY DETECTORS. Hurley, J. P.; Mathiesen, J. M.; Dagragnano, V. L. (Naval Radiological Defense Lab., San Francisco). Nucl. Instrum. Methods, 57: 109-15(Dec. 1967).

Experiments designed to study the behavior of various Ge(Li) detector systems are described. Techniques of improving energy resolution are discussed. Measurements of detector response to thermal radiation are described. A series of measurements showing the variation of line width as a function of energy is discussed. Finally, the appearance of anomalous peaks in the pulse height spectra are described. (auth)

2354 THE NONLINEAR RESPONSE OF THE PLASTIC SCINTILLATOR NE102. Badhwar, G. D.; Deney, C. L.; Dennis, B. R.; Kaplon, M. F. (Univ. of Rochester, N. Y.). Nucl. Instrum. Methods, 57: 116-20(Dec. 1967).

The response of the plastic scintillator NE102 to cosmic ray particles has been determined during two balloon flights of a double (dE/dx)E counter telescope from Fort Churchill, Canada in July and August 1966. The results have been fitted to an equation. For protons with energies between 36 and 220 MeV, the data give a value of $kB = 12.6 \pm 2.0$ mg/(cm^2 · MeV) and $C = 0$. For alpha particles with energies between 38 and 220 MeV/nucleon, $kB = 7.2 \pm 1.0$ mg/cm^2 · MeV) and $C = 0$. For carbon and oxygen nuclei with energies near 100 MeV/nucleon, the data are best fitted with $kB = 7.9$ mg/(cm^2 · MeV) and $C = -6.6 \times 10^{-6}$ mg^2/(cm^2 · MeV)^2. These results are compared with measurements made by other workers and the differences in the values of kB for different types of particles are interpreted in terms of the effects of knock-on electrons. (auth)

2355 PULSE SHAPES IN SURFACE BARRIER DETECTORS. Cohen, B. L.; Fink, C. L. (Univ. of Pittsburgh). Nucl. Instrum. Methods, 57: 93-9(Dec. 1967).

The shapes of the current pulses derived from fully depleted surface barrier detectors are observed and compared with theory. Separate measurements are made with low-energy alpha particles entering the front and back surfaces, so the pulses are due to the motion of electrons only, and holes only, respectively. These pulses should be of the same shape, but reversed in time and scaled in time in proportion to the mobilities. This is observed when there is a large over-voltage, but for lower voltages, straggling distorts the shape of the pulses from hole collection. The shapes of the electric fields in the detectors are surmised from the pulse shapes. At high voltage, the fields become much closer to uniform than is implied by the usual constant gradient assumption, and in two of the four detectors they become quite uniform. (auth)

2356 TREND REMOVAL IN COUNTING EXPERIMENTS. Cruse, D. W.; Hamilton, W. D. (Univ. of Sussex, Brighton, Eng.). Nucl. Instrum. Methods, 57: 29-36(Dec. 1967).

Recent parity violation experiments have emphasised the need for a reliable technique for determining a small difference (1 part in 10^6) between the means of two long series of data in which random and regular trends are present. The condition for ensuring that the effect of such trends is negligible is discussed and then some previously used methods for trend removal are listed. An improved technique for trend removal, based on a moving average, is introduced. Finally the distortion of the series caused by the operation of trend removal is considered and an example given of the calculation of the necessary correction factor for the standard error. (auth)

2357 THE ZnO CRYSTAL AS SENSITIVE AND SELECTIVE DETECTOR FOR ATOMIC HYDROGEN BEAMS. Haberrecker, K.; Mollwo, E.; Schreiber, H.; Hoinkes, H.; Nahr, H.; Lindner, P.; Wilsch, H. (Univ., Erlanger, Ger.). Nucl. Instrum. Methods, 57: 22-8(Dec. 1967).

The change in surface conductivity of a ZnO-single-crystal if atomic hydrogen is adsorbed is used to determine the intensity of atomic beams. The lower limit of detection is 2×10^{11} atoms/cm^2 · sec. The apparatus is described and measurements in a source for polarized protons are discussed. (auth)

2358 PROTON–DEUTERON DISCRIMINATION WITH A SINGLE SEMICONDUCTOR DETECTOR. Alberigi Quaranta, A. (Univ. of Modena, Italy); Martini, M.; Ottaviani, G.; Zanarini, G. Nucl. Instrum. Methods, 57: 131-6(Dec. 1967).

A novel method is presented which permits to discriminate protons from deuterons with a single surface-barrier detector and a very simple electronic circuitry. The energy measurement is not influenced by the particle discrimination system. (auth)

2359 A DIFFUSION CLOUD CHAMBER FOR AN INVESTIGATION OF THE PHOTOREACTIONS ON ^{3}He. Goggi, G. (Univ.,

Pavia, Italy. Istituto Nazionale di Fisica Nucleare, Pavia, Italy); Mantovani, G. C.; Marciano, C.; Piazzoli, A.; Scannicchio, D.; Argan, P. E.; Piazza, A. Nucl. Instrum. Methods, 57: 137-40 (Dec. 1967).

A somewhat unusual diffusion cloud chamber is described, constructed in order to carry out a general investigation of the photoreactions on ^{3}He. (auth)

2360 LOW LEVEL ALPHA PAIR COUNTING SYSTEM. Ryan, R. D. (Australia Atomic Energy Commission Research Establishment, Sutherland, New South Wales). Nucl. Instrum. Methods, 57: 43-5(Dec. 1967).

A low level alpha scintillation counting system is described, in which both single and pair counts are recorded on mechanical registers. A low threshold discriminator permits the operation of the photomultiplier at less than 800 V with high detection efficiency and low background level. (auth)

2361 PASSAGE OF CHARGED PARTICLES THROUGH SILICON. Skyrme, D. J. (Oxford Univ.). Nucl. Instrum. Methods, 57: 61-73(Dec. 1967).

The stopping powers ($dE/d\chi$) and ranges of protons, deuterons, tritons, ^{3}He and alpha particles in silicon were calculated and are presented for particle energies from 1 to 50 MeV. A least-squares fitting program was then used to evaluate the parameters a and b in the semi-empirical range-energy relationship $R = aE^b$. Finally, graphs are presented which show in a convenient form the distribution function of the energy loss of a monoenergetic beam of charged particles traversing a thin slice of silicon, such as dE-detector in a telescope arrangement. (auth)

2362 CHARACTERISTICS OF WINDOWLESS ELECTRON MULTIPLIERS: USE ON ROCKETS AS DETECTORS OF LOW-ENERGY AURORAL ELECTRONS. Bosqued, J. M.; Reme, H. (Centre d'Etude Spatiale des Rayonnements, Toulouse). Nucl. Instrum. Methods, 57: 6-12(Dec. 1967). (In French).

The threshold of detection for charged particles is largely reduced by using a windowless channel electron multiplier. The main characteristics of this detector are: a gain higher than 10^7, a good detection efficiency for electrons between 100 eV and 40 keV, a count rate higher than 10^5 counts/sec. This detector can work independently of the pressure from 10^{-3} Torr: thus its use is possible on rockets. Magnetic spectrometers can be made with channel multipliers to study the spectrum and angular distribution of auroral electrons from 100 eV to 40 keV. (auth)

2363 DETECTION MECHANISM IN SEMICONDUCTOR COUNTERS. Deshpande, R. Y. (Bhabha Atomic Research Centre, Bombay). Nucl. Instrum. Methods, 57: 125-30(Dec. 1967).

An attempt is made to present a consistent picture of the detection mechanism in junction-type semiconductor counters. The processes of energy loss, of creation of charge pairs, of charge separation and collection, and of signal formation in the presence of background noise, are briefly reviewed. Shockley's simple model accounting for e, and van Roosbroeck's calculation of the Fano-factor, are first described. While comparing the theory with the experimental results it is suggested that further definition of the threshold energy is necessary. It is also pointed out that the branching process of energy loss, in contrast to the collective loss mechanism, needs further theoretical clarification. The several factors which affect the charge separation and collection are then discussed. At this stage the leakage of excess charge by dielectric relaxation in the detector medium is also considered. Next, the statistical processes influencing the energy resolution are quickly described. An illustrative calculation for diffused silicon detectors, for which complete data is now available, is then performed. In this context the role of surface properties is also considered. Finally, the possibility of developing a proportional solid-state detector is hinted. (auth)

2364 ^{56}Co AS A CALIBRATION SOURCE UP TO 3.5 MeV FOR GAMMA RAY DETECTORS. Barker, P. H.; Connor, R. D. (Univ. of Manitoba, Winnipeg, Can.). Nucl. Instrum. Methods, 57: 147-51(Dec. 1967).

Energies and relative intensities of the transitions in ^{56}Fe which follow the decay of ^{56}Co were determined with Ge(Li) detectors and are presented. These results are combined with other, recent high resolution studies to give the relative intensities of the principal ^{56}Co gamma rays with an accuracy of about 3%. This provides a means of obtaining the relative efficiency of a gamma-ray detector in the energy range 800 to 3500 keV. (auth)

2365 STUDY OF COMBINATION OF WHOLE-BODY COUNTING AND PARTIAL-BODY COUNTING. Imahori, Akira (Tokyo Univ.). Radioisotopes (Tokyo), 16: 591-7(Nov. 1967). (In Japanese).

In recent years, human (whole-body) counters have been widely used in the field of health physics and nuclear medicine. A new approach to whole-body counting method using the human counter at Tokyo University is described. The marked characteristics of this human counter is its three types of detectors installed for various counting purposes. By the combination of these detectors, whole-body counting, partial-body counting, and linear scanning can be carried out simultaneously. The behavior of radioactive substances administered in human body is followed up by the combination method. The radioactivities in whole-body and partial-body of eight subjects were followed up in the period of 24 hours after the oral administration of $Na^{131}I$ by the combination method. It is shown that the combination method is available in the field of nuclear medicine and health physics, especially estimation of the dose derived from accidental intake of radioactive substances. (auth)

2366 HIGH-PRECISION ELECTROMETRIC INTEGRATING AMPLIFIER FOR MEASURING IONIZATION CURRENTS AND ELECTRIC CHARGES. Ilyukovich, A. M.; Kulikova, I. A. Izmer. Tekh., No. 8, 47-9(1967).

An electrometric integrating amplifier for measuring small direct currents and slowly changing currents is described. The input stage of the amplifier is designed using an EM-5 electrometric tetrode which has a grid current of $2-3 \times 10^{-15}$ amp. The stage is a parallel, balanced circuit with a single power source. To reduce drift the stage is adjusted so that the circuit is insensitive to supply voltage variation. This arrangement, and the use of an F120/1 photogalvanometer as the second amplifier, reduce zero drift by 1 mv or less during several hours of operation. The output voltage is measured with a microammeter with a 10-μamp scale. In addition, it is possible to measure the output voltage using the compensation method. The microammeter is used as a null indicator in a comparison circuit containing a stable reference voltage source, and which can be switched in 50-mv steps from 0 to 500 mv. An integrating circuit is included which provides 11 current measurement ranges with a fine range overlap of from 5×10^{-13}–10^{-7} A and a measurement time of 170–300 sec. The device can also measure charges from high-impedance converters (such as piezoceramic). In such an instance the time constant can be set within limits from 10^{-12} to 2×10^{-7} coulomb division. (auth)

2367 CONTAMINATION BY NATURAL RADIOACTIVE ELEMENTS OF STRUCTURAL MATERIALS USED FOR γ RADIATION SCINTILLATION COUNTERS. Semenov, G. S.; Grubkov, A. P. At. Energ. (USSR), 23: 162-3(1967). (In Russian).

The lower level of sensitivity of radiometric detecting instruments is determined by the prevailing cosmic radiation and by contamination of the structural materials by natural radioactive elements. The cosmic radiation background may be reduced by a factor of 5 to 10 by using heavy elements for shielding but the contamination present in the structural materials and in the shield itself cannot be removed. In order to clarify this problem a concentration of radioactive elements in the glass used for photomultipliers, mica and dynode materials and other components was determined. On the basis of the 238-keV ThB, 300- to 360-keV Ra(B + C), and 1.46-MeV ^{40}K lines, the results revealed that the glass, the mica, and the shielding material contributed most to the specific activity of the detector. The FEU-13 and FEU-49 type photomultipliers were found to possess the highest degree of freedom from contamination by natural radioactive materials. The potassium of the glass was responsible for the activity of that material, but radium in the glass and in magnesium oxide reflector contributed also to the background of the instrument. (TTT)

2368 EXTENSION OF THE (SIMPLE) POLYNOMIAL METHOD FOR THE INTERPRETATION OF THRESHOLD DETECTOR DATA. Cuculeanu, V. (Inst. of Atomic Physics, Bucharest). Rev. Roum. Phys., 12: 603-14(1967).

The simple polynomial method used for treating the threshold-detector activation data is extended by using a Taylor development. The results are thus much improved. The detectors should be chosen with linear independent cross-sections. The method can offer information about the fast neutron spectrum deformation in the reactor. It is intended for the smooth spectrum functions. (auth)

2369 POSSIBILITIES OF APPLYING ORGANIC SCINTILLATION DETECTORS IN MEASUREMENTS OF THE DOSE EQUIVALENT AND THE QUALITY FACTOR IN MIXED NEUTRON–GAMMA RADIATION. Pszona, Stanislaw (Inst. of Nuclear Research, Swierk, Poland). Nukleonika, 12: 547-52(1967).

The response of organic scintillation detectors in the mixed neutron–gamma radiation field was analyzed. It was proved that

it is possible to use the new system of detectors to measure the dose equivalent and the quality factor of mixed neutron–gamma radiation. The system consists of a tissue equivalent chamber and an organic scintillator. Some preliminary results are given. (auth)

2370 ERROR IN THE ABSOLUTE DETERMINATION OF DISINTEGRATION RATES OF EXTENDED SOURCES BY COINCIDENCE COUNTING WITH A SINGLE DETECTOR: APPLICATION TO ^{125}I AND ^{60}Co. Sutherland, L. G.; Buchanan, J. D. (Isotopes Inc., Palo Alto, Calif.). Int. J. Appl. Radiat. Isotop., 18: 786-7(Nov. 1967).

It is recognized that a condition for valid measurement of disintegration rates by the β-γ coincidence method is that either the β-detector or the γ-detector must be equally responsive to all parts of the source, but that a similar requirement applied to such measurements with a single detector appears not to have been generally recognized. Brinkman et al., developed a sum peak coincidence method for measuring the disintegration rates of radionuclides emitting γ-rays in coincidence, or positron annihilation radiation, using a single NaI(Tl) detector. Harper and Houtermans also developed a coincidence method for measuring the disintegration rate of ^{125}I with a single NaI(Tl) detector. A tacit assumption in the derivation of the relevant equations is that the detector is equally responsive to all parts of the source, otherwise there will be a significant error in the calculations, the magnitude of which can be estimated by numerical integration of the counting rate over the dimensions of the source. This has been done for ^{125}I and ^{60}Co. In order to satisfy the condition that the detector be equally responsive to all parts of the source, the latter should be made as small as possible (approximating a point source), or for larger samples by use of a well-type detector, which is nearly equally responsive to all parts of a source. (UK)

2371 PORTABLE NEUTRON DOSE EQUIVALENT METER. Rogers, E. J. (Brookhaven National Lab., Upton, N. Y.). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-14: No. 5, 8-14(Oct. 1967).

A portable, battery-operated fast-neutron monitor has been developed for use at reactors and accelerators. The instrument employs a polyethylene-loaded proportional counter and reads directly in biologically equivalent units for neutrons from .1 MeV to over 15 MeV on eight scales ranging from 2 mrem per hour to 6000 mrem per hour. On the lower ranges, the input pulses are integrated for electronically determined time intervals, while on the higher ranges a ratemeter mode of operation is employed. All of the electronics, including the 1400-V power supply for the proton-recoil type detector requires only 25 milliwatts of power, permitting about 500 hours of continuous operation from a small 7-V mercury battery. Electronic voltage regulation and the use of field-effect transistors in the integrating and timing circuits provide a stability of calibration far beyond that normally associated with portable survey instruments. (auth)

2372 COLLECTION TIME OF ELECTRON–HOLE PAIRS IN A COAXIAL Ge(Li) RADIATION DETECTOR. Poenaru, Dorin N. (Inst. for Atomic Physics, Bucharest). IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-14: No. 5, 1-7(Oct. 1967).

Current and electric charge pulse shapes obtained for the collection of only one electron-hole pair released by an ionizing event in the sensitive volume of a coaxial Ge(Li) detector cooled at liquid nitrogen temperature, were calculated. By considering the pairs generated in the close vicinity of the detector electrodes, as well as those created in an intermediate region, maximum and minimum durations of the current pulses have been found. Low electric field intensity is assumed (charge carrier velocity directly proportional to the electric field intensity). (auth)

2373 USE OF LOW EFFICIENCY DETECTORS IN THE STANDARDIZATION OF BETA-GAMMA EMITTING RADIONUCLIDES. Vayrynen, Heikki (Univ. of Helsinki). Int. J. Appl. Radiat. Isotop., 18: 755-60(Nov. 1967).

A coincidence method using low efficiency scintillation detectors in determining the absolute activity of some beta–gamma emitting nuclides. The general pulse rate equations are given and these are applied to the important case of ^{198}Au. In this case an explicit expression is derived for the relevant correction terms. (auth)

2374 SCINTILLATION DETECTOR FOR THE MEASUREMENT OF THERMAL NEUTRONS IN SUBCRITICAL ASSEMBLY. Tojo, Takao (Japan Atomic Energy Research Inst., Tokyo); Niwa, Takeo; Nakajima, Tadashi; Kondo, Makoto. J. Nucl. Sci. Technol. (Tokyo), 4: 512-17(Oct. 1967).

With the view toward measuring neutron flux in a subcritical assembly, a detector consisting of a γ-ray insensitive scintillator based on ^{6}LiF, ZnS(Ag) and polyethylene combined with a long light guide has been developed. A description is given of performance obtained with this detector, in comparison with BF_3 counters and glass scintillator. It has proved that the newly deviced detector with 16 mm diam. × 0.42 mm thick scintillator is almost comparable in detection efficiency to a BF_3 gas filled counter (40 cmHg, 96% ^{10}B) having the effective dimensions of 16 mm diam. × 70 mm. The fine spatial resolution obtained with the detector is demonstrated by actual measurements of neutron flux distribution in the assembly. (auth)

2375 DETECTION OF NATURAL γ RADIATION IN PETROLEUM EXPLORATION BOREHOLES. Johnstone, C. W. (Schlumberger Well Surveying Corp., Houston, Tex.). pp. 115-27 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

An introduction into the purpose and scope of gamma-ray logging is presented. A brief description of the instrumentation required for the borehole environment is included. (B.G.D.)

2376 A DEVICE TO MEASURE ^{228}Th AT NATURAL LEVELS. Hursh, John B.; Lovaas, Arvin (Univ. of Rochester, N. Y.). pp 345-52 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

A method for determining the thorium-228 content in natural materials is described. The method resolves itself into a measurement of the radon-220 gas generated which is accomplished by scintillation techniques. Data are presented for rock samples tested. (W.H.K.)

2377 DETECTOR FOR ^{222}Rn MEASUREMENTS AT VERY LOW LEVEL. Di Ferrante, Elvira R.; Gourski, Eric; Boulenger, Rene R. (Centre d'Etude de l'Energie Nucleaire, Mol-Donk, Belg.). pp 353-7 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

A method for determining the radium-226 content of low-level samples by the emanation technique is discussed. Design of a scintillation detector for emanated radon-222 is described. Examples of measurements on environmental samples are presented. (W.H.K.)

2378 THIN-WALL ION CHAMBERS FOR LOW-LEVEL RADIATION ENVIRONMENT. Shamos, M. H.; Liboff, A.; Siderowitz, J. (New York Univ., N. Y.). pp 627-41 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

The design of thin-wall ionization chambers for measuring the environmental radiation is presented. They are filled with electronegative gases, such as Freon-12, and operated at low collecting fields to induce columnar recombination of the ions in the alpha tracks arising from radioactive contamination of the chamber walls. (W.H.K.)

2379 MEASUREMENT OF ENVIRONMENTAL RADIATION WITH PLASTIC SCINTILLATORS. Wensel, A. (Johann Wolfgang Goethe Univ., Frankfurt am Main). pp 643-54 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

The design and performance of a plastic scintillation detector for measuring low gamma dose rates are presented. The detector is designed to have a high sensitivity, be energy-independent, and be insensitive to mechanical vibrations for mobile monitoring. (W.H.K.)

2380 A MUSCLE-EQUIVALENT ENVIRONMENTAL RADIATION METER OF EXTREME SENSITIVITY. Kastner, Jacob (Argonne National Lab., Ill.); Rose, John E; Shonka, Francis R. pp 655-60 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

A portable system for measuring the environmental radiation dose to man is described. A vibrating quartz fiber electrometer and a muscle-equivalent ionization chamber comprise the extremely sensitive radiation meter. (W.H.K.)

2381 INSTRUMENTATION FOR AERIAL SURVEYS OF TERRESTRIAL γ RADIATION. Hand, John E. (Edgerton, Germeshausen and Grier, Inc., Goleta, Calif.). pp 687-704 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

A system for simultaneously recording gamma activity and ground-position values for aerial surveying is presented. The scintillation detector is equipped with an altitude compensator, and the aircraft position is controlled by a Doppler navigation system. The data recording system records the information on paper tape for visual evaluation and also on punched tape for computer processing. (W.H.K.)

2382 STUDIES OF ENVIRONMENTAL RADIATION AT A PARTICULAR SITE WITH A STATIC γ-RAY MONITOR. Burch, P. R. J.; Duggleby, J. C.; Oldroyd, B.; Spiers, F. W. (Univ. of Leeds, Eng.). pp 767-779 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

The construction and performance of a large static background monitor are described. The apparatus consists of four large disk-shaped high-pressure ionization chambers mounted on top of one another and placed in an open-ended cylindrical steel shield. The ionization chambers are shielded and positioned to monitor cosmic radiation and gamma radiation from the atmosphere, soft cosmic radiation, hard cosmic radiation, and ground gamma radiation. (W.H.K.)

2383 ENVIRONMENTAL γ-RAY DOSE TO POPULATIONS: SURVEYS MADE WITH A PORTABLE METER. Spiers, F. W.; McHugh, M. J.; Appleby, D. B. (Univ. of Leeds, Eng.). pp 885-905 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

The design of a high-pressure ionization chamber for background gamma-radiation dosimetry with high sensitivity and long-term stability of response is presented. Methods of calibration and basic testing of the instrument are discussed, and its application to the problem of determining the average dose to populations in some localities in Britain is described. (W.H.K.)

2384 POLUPROVODNIKOVYE DETEKTORY YADERNYKH CHASTITS I IKH PRIMENENIE. (Semiconductor Detectors of Nuclear Particles and Their Application). Akimova, Yu. K. (ed.). Moscow, Atomizdat, 1967. 256p.

The physical characteristics and experimental applications of semiconductor detectors for recording nuclear particles are discussed. The problems involving maximum signal-to-noise ratio in electronic equipment used with semiconductor detectors and signal formation in preamplifiers and amplifiers are analyzed. The use of semiconductor detectors in nuclear spectroscopy and for measurements of cosmic radiation is described. The effects of radiation on these detectors is evaluated. (R.V.J.)

2385 PARTICLE DETECTOR. Lansiart, Alain; Leloup, Jean; Lequais, Jean (to Commissariat a l'Energie Atomique). British Patent 1,089,018. Nov. 1, 1967. Priority date Apr. 17, 1964, France.

The design of a spark chamber for detecting beta particles, x rays, and gamma rays is presented. A low-voltage non-pulsed circuit is used. Argon and methane at atmospheric pressure are used in the chamber. (W.H.K.)

2386 DISPLAY APPARATUS FOR USE WITH RADIATION DETECTORS OR THE LIKE. Saunders, Patrick William (to E. K. Cole Ltd.). British Patent 1,090,451. Nov. 8, 1967. Filed Mar. 13, 1964.

Specifications for a display system for scintillation radiation detectors are presented. A pulse-height analyzer distinguishes the energy of the incident radiation and codes this information for further processing. The system provides a method for comparing the relative activity at different localities on the face of the scintillating crystal. (W.H.K.)

2387 IZMERENIE MALYKH AKTIVNOSTEI RADIOAKTIVNYKH PREPARATOV. (Measurement of the Low Activity of Radioactive Preparations). Dement'ev, V. A. Moscow, Atomizdat, 1967. 140p.

Questions on the sensitivity of radiometric devices, designed for the measurement of low activities, were examined on the basic statistical regularities of the registration of nuclear radiation. The connection of sensitivity with the type of the device, the counting efficiency, and the total measurement time was given. For devices in which the cosmic components of the background are suppressed, the concept of uniformity of the background was introduced. It was shown that such installations have twice as high a sensitivity of the usual installation. Methods of increasing the sensitivity of detectors were examined. New methods for reducing the cosmic portion of the background without modification of the anticoincidence device were described. (tr-auth)

Nuclear Spectroscopic Instrumentation

Refer also to abstracts 2288, 2363, 2457, and 3180.

2388 (AWRE-O-8/67) RESOLUTION CORRECTIONS TO NEUTRON SPECTROMETRY BY THE PULSED SOURCE TIME OF FLIGHT TECHNIQUE. Paterson, W. J.; Shutler, K. L. (Atomic Weapons Research Establishment, Aldermaston England)). Sept. 1967. 17p. Dep. CFSTI. UK 3s.

The resolution correction method in the code TOF, used in the analysis of time-of-flight measurements on the VERA reactor, is described, with an account of some investigations using the code TOFTEST to determine the range of validity of this correction applied to typical results. (auth)

2389 (CEA-R-3247) ENSEMBLE AUTOMATIQUE DE COMPENSATION DU CHAMP TERRESTRE AUTOUR D'UN SPECTROMETRE BETA. (Automatic Device for Compensating the Earths Magnetic Field Around a β Spectrometer). Ristori, Christian (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). Aug. 1967. 74p. (In French). Dep.

Thesis. Submitted to Univ., Grenoble, France

It is shown how the earth's magnetic field inside a double focusing, $\pi\sqrt{2}$, iron-free, beta spectrometer (radius 50 cm) was compensated. Three orthogonal magnetic fields are generated by three sets of square coils. Each stabilized power supply is regulated through its own magnetometer (of the fluxgate type) and the earth field inside the spectrometer is compensated to 10^{-4}Oe whatever the earth field or power supply oscillation could be. (auth)

2390 (CEA-R-3252) FORMATION ET AMPLIFICATION LINEAIRE DES SIGNAUX EN SPECTROSCOPIE NUCLEAIRE. (Formation and Linear Amplification of Signals in Nuclear Spectroscopy). Le Du, Rene; Meites, Jean-Daniel (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Sept. 1967. 15p. (In French). Dep.

The apparatus described can be associated to various detectors used in nuclear physics, either rapid, its rise time is always under 30 nanoseconds, or slow, because of its continuous connections. Its gain can be increased very progressively from 2000 to 10 by increasing the feedback factors. The maximum permissible entry voltage, without causing any increase in the dead-time is 12 volts, whatever the value of the gain. The device is fitted with two continuous exits giving signals of equal amplitude but of opposite sign (10 volt pulses followed by a 4 volt undershoot). Its controls, all accessible, make it possible to adapt the apparatus very rapidly to various measurements. It is completely transistorized and the amplifier is fitted into a Renatran 2/8 drawer. A gain 4 preamplifier in the same drawer makes it possible to obtain a total gain of 8000. (auth)

2391 (INP-533/PL) ANALIZA WIDM PROGRAM NA MASZYNE ODRA 1003. (Analysis of Spectra Program for Computer ODRA 1003). Slizynski, A. (Institute of Nuclear Physics, Krakow (Poland)). 1967. 36p. (In Polish). Dep.

A numerical method and program in the MOST –1 language for the ODRA 1003 computer is presented for numerical analysis of spectra by means of the least squares method. Several superposed spectral lines with normal distributions could be separated in the presence of a linear background. (auth)

2392 (JINR-P13-3437) SVETOSIL'NYI LINZOVYI β-SPEKTROMETR SOVPADENII S TREUGOL'NOI FORMOI MAGNITNOGO POLYA. (Fast Coincidence β Spectrometer With a Triangular-Shaped Magnetic Field). Morozov, V. A.; Muminov, T. M. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1967. 21p. (In Russian). Dep.

A fast coincidence β spectrometer with triangular-shaped magnetic field was constructed, based on the Gerholm spectrometer. The focusing properties of the triangular magnetic field were calculated. The electron–optical system and the recording system of the spectrometer are described. The modifications made to the basic Gerholm spectrometer led to an increased degree of the azimuthal symmetry of the magnetic field and improvement of its characteristics. (J.S.R.)

2393 (JINR-P13-3523) ISOTOCHNIK REPERNYKH SIGNALOV DLYA SPEKTROMETRICHESKIKH STSINTILLYATSIONNYKH SCHETCHIKOV NA OSNOVE ELEKTROLYMINESTSENTNYKH DIODOV. (Source of Reference Signals for Spectrometric Scintillation Counters Based on Electroluminescent Diodes). Omelynenko, M. N.; Tyupikov, V. K.; Filchenkov, V. V. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1967. 9p. (In Russian). Dep.

An oscillator of reference signals for scintillation spectrometers based on the SiC and GaP electroluminescent diodes is described. The pulse width being 0.5–1 μs and the rise time 0.1–0.2 μs. The womp brightness is regulated in the range corresponding to the scintillation amplitudes while recording the 1–15 MeV neutrons. The temperature instability is compensated and can be less than 0.2%/°C. (auth)

2394 (JINR-P13-3549) SPEKTROMETR PO VREMENI PROLETA NANOSEKUNDNOGO DIAPAZONA. (Time-of-Flight Spectrometer of Nanosecond Range). Lapshin, V. G.; Petrukhin, V. I.; Rykalin, V. I.; Khazins, D. M.; Tsisek, Z. (Joint Inst. of Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1967. 14p. (In Russian). Dep.

A time-of-flight nanosecond-range spectrometer is described. Resolution of the spectrometer is 0.44 ns; the path length is changed from 4 to 14 m. The spectrometer has a feedback, which stabilizes the time spectra during many-hour expositions with the accuracy of $\pm 3.10^{-12}$ sec. (auth)

2395 (LA-3752) A 90° ^{3}He NEUTRON SPECTROMETER. Brown, W. K.; Ellis, A. N.; Peterson, D. D. (Los Alamos Scientific Lab., N. Mex.). Sept. 20, 1967. 24p. Dep. CFSTI.

A fast ^{3}He neutron spectrometer has been developed that is free of recoil spectrum effects. Positioning solid-state detectors outside the neutron beam at 90° yields this advantage, and precludes nuclear reactions in the detectors themselves. Operating in conjunction with a pulse-height analyzer, the spectrometer covers the energy range $0.1 < E_n < 6$ MeV, or higher, with an energy resolution of ~±10%. In a time-of-flight, current signal operating mode, the energy range is extended to very low neutron energies. The spectrometer was used in the latter manner to measure the neutron spectrum of the Persimmon experiment conducted at the Nevada Test Site in February 1967. (auth)

2396 (ORNL-IIC-10(Vol.1), pp 18-35) INTRODUCTION TO MOESSBAUER SPECTROSCOPY. Collins, R. L. (Texas Univ., Austin. Dept. of Physics).

Mössbauer spectroscopy furnishes a sensitive tool for examination of the immediate chemical environment of many nuclei. This is not a technique suited to trace element analysis, but sensitivity compares favorably with other tools such as x-ray diffraction. Major effects in the spectra correspond to "s" electron density, the electric field gradient tensor, and the existence of strong magnetic fields. Advances in theory and apparatus are being made, and this opens additional areas to investigation by means of the Mössbauer effect. (auth)

2397 (ORNL-IIC-10(Vol.1), pp 142-56) FAST MOESSBAUER DATA-COLLECTION SYSTEM. Page, John Guy; Jagger, James W. (Applied Nuclear Corp., Austin, Tex.); Collins, R. L. (Austin Science Associates, Inc., Tex.).

The attainment of adequate signal/noise in Moessbauer spectroscopy has been limited by the pulse handling electronics. An improvement by a factor of five in acquisition rate for ^{57}Fe was achieved by careful attention to circuit parameters. The time for 10^6 counts per channel, on a 400-channel analyzer, is 1 to 2 hours. Useful applications are expected in analytical determinations, difficult compounds such as biochemicals and heterogeneous catalysts, and for improved productivity in general spectrometry. (auth)

2398 (ORNL-IIC-10(Vol.1), pp 157-74) MULTIPLEX FOR DUAL-SPECTRUM MOESSBAUER SPECTROMETRY. Ruegg, F. C. (National Bureau of Standards, Washington, D. C.).

It is often desirable to have the capability of accumulating two Moessbauer spectra simultaneously with both spectra having exactly the same Doppler velocity dependence. This is possible with a multiplexing system which allows accumulation of two spectra simultaneously and storing of each spectrum in a 200-channel subgroup of a multichannel analyzer. The memory of the analyzer, which is operated in the time mode, is used on a demand basis by the two detector systems, and the counts are routed to the proper subgroup in complementary channel locations, i.e., the channel location in the second subgroup is the channel number in the first subgroup plus 200. The logic, circuitry and performance are described. (auth)

2399 (ORNL-IIC-10(Vol.1), pp 175-96) A MULTI-SPECTROMETER MOESSBAUER SYSTEM USING AN ON-LINE COMPUTER. Goodman, R. H. (Department of Energy, Mines and Resources, Ottawa (Ontario). Mines Branch).

The use of an on-line computer for Moessbauer spectroscopy is discussed. A system of sequentially controlling experiments and monitoring experimental parameters is described. The interface techniques of the computer and a commercially available Moessbauer spectrometer are given. Several different approaches are described and the relative merits of each are presented. The application of this system is illustrated by describing a study of certain iron-copper-sulphur compounds. (auth)

2400 (ORNL-IIC-10(Vol.1), pp 356-75) REALISATION AND USE OF X-RAY FILTERS FOR ENERGY SELECTION. Broquet, Claude; Robin, Gerard; Vacher, Michel (Atome Industriel, Chatillon-sous-Bagneux (France)).

Several techniques were developed for the fabrication of balanced filters. Good results were obtained for almost all filters necessary for the analysis of the most common elements between Z = 20 and Z = 83. Rolling is easy, but is restricted to about ten elements; electrolysis is used for a few elements; the most general technique is encapsulation in resins. The filters tested show a homogeneity and an accuracy of about 2 to 10%; it is expected that 5% accuracy can be obtained for all of them, which is quite sufficient for practical applications. These filters are now commercially available, and we hope that this new possibility will help to promote new applications of the X-Ray fluorescence technique. (auth)

2401 (ORNL-IIC-10(Vol.1), pp 424-41) REVIEW OF SOLID-STATE DETECTOR SYSTEMS FOR X-RAY SPECTROMETRY. Heath, R. L. (Idaho Nuclear Corp., Idaho Falls).

Recent developments in fabrication techniques for lithium-ion drifted germanium and silicon detectors and low-noise electronics have resulted in improved performance for x-ray and gamma-ray spectrometers employing these devices. A general review of the characteristics of detectors and associated electronic systems for use in x-ray spectrometry is presented. Topics in the discussion will include a description of the optimum operating parameters for detectors, considerations in the design of low-noise preamplifiers employing field-effect transistors, instrumental requirements for high-resolution systems, and methods which can be applied for data analysis. Practical laboratory x-ray spectrometer systems using commercially available equipment are described. Data are presented which were obtained on a system which exhibits an energy resolution of 420 eV (FWHM) for 6-keV photons. Practical examples of the application of this system to x-ray spectrometry will be presented. Fluorescent excited x-ray spectra are shown for the elements from chlorine to lead. (auth)

2402 (PG-Report-792) THE EXPERIMENTAL DETERMINATION OF THE PHOTOPEAK EFFICIENCIES OF NaI(Tl) DETECTORS FOR CYLINDRICAL GASEOUS SOURCES. Barnes, V.; Wilson, J. J. (United Kingdom Atomic Energy Authority, Sellafield (England). Production Group). 1967. 9p. Dep. CFSTI. UK 1s. 9d.

A technique is described whereby the photopeak efficiency of a NaI(Tl) spectrometer for a gaseous source of a gamma-emitting isotope may be determined without reference to a standard gaseous source. The method makes use of calibrated solutions of radioactive isotopes which emit gamma photons of energy close to that of the radioactive gas to be measured. A knowledge of the abundance of the unconverted gamma photons emitted by the calibrated solutions and by the gaseous isotope is also required. The underlying theory and the experimental details of the technique are described and also experiments to test the validity of results. Factors affecting the accuracy of the results are discussed and the variation of photopeak efficiency with photon energy is given for a 3 in. × 2 in. diameter gaseous source resting on a 3 in. × 3 in. NaI(Tl) crystal. (auth)

2403 (RT/EL-(67)1) RIVELATORI AL SILICIO DEL TIPO A BARRIERA SUPERFICIALE PER SPETTROMETRIA α E β AD ALTA RISOLUZIONE. (High Resolution Surface Barriers of Silicon for High Resolution Alpha and Beta Spectrometry). Coiante, D.; Presicce, L. Parisi; Spoglia, U. (Comitato Nazionale per l'Energia Nucleaire, Rome (Italy)). 1967. 19p. (In Italian). Dep.

The present work describes a method permitting to make high resolution surface barrier silicon radiation detectors. Some α and β spectrometry measurements are also shown. (auth)

2404 (RT/EL-(67)4) COORDINAMENTO DELLE ATTIVITA NEL CAMPO DELL'ELETTRONICA E DELLA STRUMENTAZIONE. RAPPORTO N. 1. RIVELAZIONE DI RADIAZIONI. (A Review of Studies in the Field of Electronics and Instrumentation. Report No. 1. Studies on Radiation). Rispoli, B. (Comitato Nazionale per l'Energie Nucleare, Rome (Italy)). 1967. 81p. (In Italian). Dep.

A series of meetings were held to coordinate work and research at Italian laboratories on electronics and instrumentation. Papers were presented reviewing the work done at Casaccia, Frascati, Bologna, and the Ionizing Gas Laboratory. Abstracts were given of papers published on counter tubes and thermopiles for neutrons, thermoluminescence, neutron detectors, ionization chambers, $\gamma-\gamma$ coincidence spectrometer, measurement of neutrons from pulse sources, techniques used for electromagnetic radiations, scintillation chambers, image intensifiers, detectors for measurement of neutron dose and flux, and Perlow neutron spectrometer. Two papers were presented in full: "Silicon Detectors of the Surface Barrier Type for High Resolution α and β Spectrometry" and "Complex for Measurement of Thermoluminescence." In the first paper the technological procedures for preparation of Si surface barrier detectors are outlined and methods for improving their resolving power are indicated. The particular techniques used at Casaccia are described in detail. The characteristics of the Si detectors obtained were measured and the results are reported. In the second paper an installation for the measurement of thermoluminescence is described. The installation consists of a unit for the detection

and measurement of the thermoluminescence and of a thermocontrol unit. Each unit is described in detail. (J.S.R.)

2405 PHOTOPEAK ANALYSIS PROGRAM FOR PHOTON ENERGY AND INTENSITY DETERMINATIONS, Ge(Li) AND NaI (Tl) SPECTROMETERS. Helmer, R. G. (Idaho Nuclear Corp., Idaho Falls); Heath, R. L.; Putnam, M.; Gipson, D. H. Nucl. Instrum. Methods, 57: 46-57(Dec. 1967).

A description is given of a method of analyzing gamma-ray spectra measured with lithium-ion drifted germanium and NaI(Tl) multichannel spectrometers. This method is based on a computer program which determines the parameters (peak position and area) of the Gaussian function which best fits the data points in a particular peak. This program includes corrections for the deviation from linearity of the electronics system and the efficiency of the detector system. Some of the peaks can have energies assigned for calibration purposes. Gamma-ray energies and intensities can then be computed for all the peaks in a spectrum. From the quality of the fit to the calibration lines and the uncertainty in the peak location, an estimate of the uncertainty in each energy is computed. Examples are given of the amount of computer input needed, of the quality of the results, and of the form of the output. Results are presented in which the computed uncertainties (i.e., internal consistency) in the energies are as small as 0.01 keV at 200 keV and 0.02 keV at 1200 keV. (auth)

2406 SLOW NEUTRON SCATTERING BY THE BRIGHT LINE TECHNIQUE. Garnsworthy, R. K.; Broomhall, G. J. (Univ. of Melbourne). Nucl. Instrum. Methods, 57: 82-8(Dec. 1967).

A spectrometer for measuring slow neutron scattering cross sections is described. The method involves the use of a "bright line" geometry, and the purpose of this paper is to relate experiences gained using the technique. In order to check the method, values of $g\Gamma_n^2/\Gamma$ have been determined for several tungsten resonances and for one cobalt resonance. These values are in agreement with previous results obtained by different methods. (auth)

2407 FAST NEUTRON RESPONSE OF ORGANIC SCINTILLATORS. Chatterjee, Arun; Ghose, A. M. (Bose Inst., Calcutta). Trans. Bose Res. Inst. (Calcutta), 29: 25-38(Mar. 1966).

Fast neutron response of NE102 plastic scintillator, a typical organic scintillator, was studied to develop a method for the absolute measurement of fast neutron intensity. The recoil proton spectrum was corrected for anisotropy of p-n scattering in the cms, multiple scattering, escape protons, etc. Pulse height–energy relationship was derived analytically from Birks' semiempirical relationship. Statistical spread was considered. The results were verified using spherical and cylindrical detectors exposed to 14.8-MeV neutrons. Absolute method of neutron flux determination based on these studies was checked by measuring (n,2n) cross-sections of nuclei. (auth)

2408 CRYSTAL MOSAIC SPREAD MEASUREMENT BY MEANS OF A NEUTRON TWO-AXIS SPECTROMETER. Rauch, H. (Oesterreichische Hochschule, Vienna). Atomkernenergie, 12: 395-8(1967). (In German).

The half widths of the reflection curves were determined from the measured intensity distributions by two methods: the crystal and detector arm were coupled 1:2 and the rocking curves were measured in parallel as well as in antiparallel position. The measurement was carried out with a large Pb-single crystal at various neutron wave lengths, various crystal thicknesses and various parallel planes. The most favorable measurement conditions and the connection between the width of the reflection curve and the mosaic spread are discussed. (auth)

2409 DOUBLE SUMMATION SCHEME IN A SCINTILLATION NEUTRON SPECTROMETER WITH γ BACKGROUND DISCRIMINATION BY THE LUMINESCENCE TIME. Kukhtevich, V. I; Trykov, L. A.; Trykov, O. A. Prib. Tekh. Eksp., No. 2, 45-9(Mar.-Apr. 1967). (In Russian).

The discrimination scheme of γ quanta by luminescence time was described. It permits the spectrometry of neutrons with threshold energy $E_n = 0.2$ MeV with a discrimination for γ quanta of $\sim 5 \times 10^{-4}$ from 0.2 to 0.3 MeV. Such a value of the energy threshold, with indicated coefficient of depression of the γ quanta, was reached by means of double summation in the compensation scheme as a result of which was eliminated the positive ejections, caused by high-energy γ quanta. The energy distribution from Ra + Be and Po + Be sources was given as an illustration of the operation of the spectrometer. (tr-auth)

2410 GAMMA-RAY SPECTROMETRY AND ITS ANALYTICAL APPLICATIONS. Lanfranco, G. (Centro Ricerche Metallurgiche S.p.A., Turin). Met. Ital., 16: 601-14(July 1967). (In Italian).

Operating procedures are described of thallium-activated sodium iodide and semiconductor gamma-ray detectors, as well as generation modes of gamma-ray spectrums, factors affecting their shape, and equipment for their analysis. Methods are mentioned for irradiating samples and for calculating activity induced in them. Qualitative and quantitative evaluation of spectra are discussed, as well as analytical sensibility and causes of error affecting gamma-ray spectrometry. (auth)

2411 EXAMINATION OF THE RADIOACTIVE PURITY OF ISOTOPIC PREPARATIONS BY MEANS OF Ge(Li) SEMICONDUCTOR AND NaI(Tl) SCINTILLATION DETECTORS. Veres, Arpad; Uchrin, Janos; Bedrosszian, Peter; Uchrin, Gyorgy (Isotope Inst. of Hungarian Academy of Sciences). Magy. Fiz. Foly., 15: 365-76(1967). (In Hungarian).

A transistorized, 256-channel analyzer was used to evaluate the spectra of isotopes obtained by semiconductor and scintillation detectors for the purpose of determining the presence of foreign admixtures. The materials to be analyzed were used in the form of thin foils in order to minimize the effect of self-absorption and scattering. The linearity of the NaI(Tl) scintillation detector in the 59.6 to 1330-keV range was checked at 7 γ-ray energies against known reference standards. The germanium semiconductor detector was prepared by the lithium-drift technique. Ten "pure" isotopes and a mixture of two isotopes, —^{22}Na, ^{51}Cr, ^{57}Co, ^{110m}Ag, ^{133}Ba, ^{137}Cs, ^{192}Ir, ^{198}Au, and ^{187}W + ^{72}Ga, —were examined by the 2 instruments. The results revealed that the Ge(Li) semiconductor detector presents several advantages over the scintillation instrument for detecting foreign contaminants in isotopes. It was also concluded that the use of a multichannel analyzer is also important for detection of the γ radiation resulting from the decay of the various natural and artificial radioisotopes. (TTT)

2412 COSMIC-RAY CONTRIBUTION TO THE BACKGROUND OF LOW-LEVEL SCINTILLATION SPECTROMETERS. May, Harold; Marinelli, Leonidas D. (Argonne National Lab., Ill.). pp 463-80 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

A study to evaluate the cosmic ray contribution to the background count of low-level scintillation detectors is presented. The principal components of cosmic rays and the major physical processes of interaction and decay giving rise to low-energy photons are discussed. Measurements were made with a sodium iodide detector with different amounts of overhead shielding. (W.H.K.)

2413 LABORATORY γ-RAY SPECTROMETER FOR GEOCHEMICAL STUDIES. Adams, J. A. S. (Rice Univ., Houston, Tex.). pp 485-97 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

The gamma-spectroscopy laboratory at Rice University is described. The shielding and surroundings, detectors and instrumentation, spectrum analysis techniques, sample preparation, and calibration standards are discussed. The radiometric determination of thorium, uranium, and potassium is discussed. (W.H.K.)

2414 PORTABLE γ-RAY SPECTROMETER FOR FIELD DETERMINATION OF THORIUM, URANIUM, AND POTASSIUM. Adams, J. A. S.; Fryer, G. E. (Rice Univ., Houston, Tex.). pp 577-96 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago University of Chicago Press, 1964.

The design, construction, and field use of portable gamma-ray spectrometers to determine thorium, uranium, and potassium in the field are discussed. The detector used is a cesium iodide scintillation crystal. A general evaluation of the field instrument is presented. (W.H.K.)

2415 FEASIBILITY STUDIES FOR THE ESTABLISHMENT OF PARAMETERS FOR BACKGROUND RADIATION MEASUREMENTS. Grune, Werner N.; McHaffey, Joseph H.; Kaplan, Charles H.; Erb, Tom L. (Georgia Inst. of Tech., Atlanta). pp 661-86 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

A study to develop an accurate field method for the detection and analysis of naturally occurring radioactivity is presented. A method for radon-222 and radium-226 analysis is described. The development of a three-channel gamma-energy analyzer, a Compton-shift eliminator, and an automatic air sampling unit is discussed. (W.H.K.)

2416 MOESSBAUER EFFECT SPECTROMETER WITH INCREASED PRECISION OF VELOCITY DETERMINATION. Sawicki, Aleksander (Inst. of Nuclear Research, Swierk, Poland); Michalski, Mieczyslaw; Piekoszewski, Jerzy. Nukleonika, 12: 537-46(1967).

An interesting arrangement for the time analyzer of the velocity spectrometer for Moessbauer experiments is given. It allows to measure velocity spectra with a much higher time resolution than it would result from the time analyzer possibilities. (auth)

2417 SPECTROMETER FOR HIGH-ENERGY COSMIC-RAY PARTICLES DESIGNED FOR PROTON SATELLITES. Grigorov, N. L.; Kakhidze, G. P.; Nesterov, V. E.; Rapoport, I. D.; Savenko, I. A.; Smirnov, A. V.; Titenkov, A. F.; Shishkov, P. P. Kosm. Issled., 5: 383-94(1967). (In Russian).

A description is given of a spectrometer carried by the "Proton" spacecraft to study the energy and charge spectra of primary cosmic-ray particles with energies greater than 10^{10} eV and to measure cross sections of the inelastic interaction of protons with carbon and hydrogen nuclei. A schematic drawing of the instrument is shown. It consists of the following basic elements: (1) an energy detector for measuring the energy (E) of each particle; (2) polyethylene and graphite targets for measuring cross sections (σ) of inelastic interactions of protons with protons and nuclei of carbon; (3) proportional counters for measuring charges (z) of primary cosmic particles; (4) an interaction detector for recording events in which a primary proton of given energy interacts with target material; and (5) electronic blocks for selecting and registering all important parameters. The spectrometer consists of two independent sections, each representing a complete instrument capable of performing the entire measurement procedure. The energy detector is an ionization calorimeter, made of iron, whose ionization chambers have been replaced by plastic scintillators. The ionization calorimeter consists of 9 steel plates (each 5.5 cm thick) and 10 layers of plastic scintillators mounted between the steel plates and below and above the ionization calorimeter. All 10 layers of plastic scintillators are closed, on the side of the ionization calorimeter, by a diffusor which is in the form of a tetragonal pyramid in whose upper section photomultipliers are located. The interaction detector performs two functions: it records the number of relativistic particles in a shower passing through it, and together with the lower scintillation counter, it produces a specific solid angle within which the particles are recorded. The entire measurement program is reduced to a multidimensional amplitude analysis. This problem is solved by transmitting pulses from the detectors and proportional counters to a system of amplitude discriminators of the integral and differential types. (ATD)

2418 ANNULAR LITHIUM-DRIFTED GERMANIUM DETECTOR FOR STUDYING NUCLEAR REACTION GAMMA RAYS. Levy, Arthur James. Charlottesville, Va., Univ. of Virginia, 1966. 223p.

Thesis.

The effect of source distance, h_γ, on intrinsic photoefficiency was measured. Graphs of intrinsic efficiency vs. E_γ for the photopeak, double-escape peak and single escape peaks are presented as well as graphs giving ratios of double-escape to photopeak efficiency vs. E_γ, full-energy to single escape efficiency vs. E_γ, and double-escape to single-escape efficiency vs. E_γ. One such Ge(Li) annulus was used as the center crystal of a three-crystal spectrometer to study the ^{24}Mg gamma decay following the ^{23}Na(d,n)^{24}Mg reaction. The deuteron bombarding energy was 0.990 MeV. Of the 64 observed transitions attributed to the decay of ^{24}Mg, 35 of these are unreported in the literature. 103 additional transitions remain unidentified. The ^{24}Mg state at 9.5 MeV (4^+,6^+) and 8.44 MeV are observed to be doublets as was recently suggested by Ollerhead, et. al., at Chalk River. The energies of these doublets measured in the present work are 9528 ± 3 keV, 9508 ± 7 keV and 8437 ± 4 keV, 8424 ± 3 keV. The use of a Ge(Li) detector has permitted clear observation of many of the transitions so that branching ratios previously reported by Endt and Van der Leun have been refined. (Disser. Abstr.)

High Energy Physics Instrumentation

Refer also to abstract 3235.

2419 (UCRL-17695) COMPUTER-CONTROLLED DATA REDUCTION OF SPARK CHAMBER FILM. Zurlinden, Donald (California Univ., Berkeley. Lawrence Radiation Lab.). July 27, 1967. Contract W-7405-eng-48. 19p. Dep. CFSTI.

An automatic scanning and measuring system was developed for the reduction of data from spark chamber film. (auth)

2420 LARGE SCATTERING CHAMBER OF SLIDING CYLINDER TYPE. Sanada, J. (Tokyo Univ.). Nucl. Instrum. Methods, 57: 58-60(Dec. 1967).

The construction and performance of a large scattering chamber for the accurate measurements of the differential cross sections of nuclear reactions is presented. The distance between the target center and the detector was 150 cm. The chamber was constructed from a fixed cylinder and a rotative cylinder. An "L" shaped rubber seal was installed on the outer wall of the fixed cylinder. An extension of this type is also discussed. (auth)

2421 ON THE LIMITATION OF THE OWEN-BATCHELOR METHOD OF PULSE SHAPE DISCRIMINATION IN A PHOTOMULTIPLIER AGAINST HIGH ENERGY ELECTRONS AND MUONS. Doke, T. (Tokyo Univ.); Adachi, M.; Kubota, S.; Ogawa, I. Nucl. Instrum. Methods, 57: 163-6(Dec. 1967).

A proposal is made on the origin of the high-energy limit for the Owen-Batchelor method of pulse shape discrimination in a photomultiplier between recoil protons and energetic electrons or muons. According to the proposed mechanism, the initial negative swing of a voltage pulse on the last dynode becomes so large for a high energy electron or a muon, that the space-charge effect between the last dynode and the anode would be appreciably reduced as a result of temporary enhancement in the potential difference across the space. This would give rise to a "saturation" of the negative amplitude of the last-dynode voltage pulse against the linear pulse-height, and would result in a rapid increase in the "Owen pulse-height" V_p (the positive amplitude of a last-dynode pulse), as well as in a rapid decrease in the zero-cross-over time t_0 of the last-dynode pulse, with increasing linear pulse-height. In consequence, the discriminating power would be progressively deteriorated as the linear pulse-height (or the energy deposit E_e in the scintillator) for an electron or a muon exceeds a certain upper limit. Approximate expressions for V_p and t_0 are derived as a function of E_e, together with a relation between V_p and t_0. Several experimental evidences are presented for the proposed mechanism, including the improving effect of added capacity in the last-dynode circuit as observed recently by Hiramoto et al. It is remarked that the breakdown of discrimination using V_p is necessarily associated with the failure of another method using t_0, owing to the presence of a definite relation between V_p and t_0. (auth)

2422 PROTOTYPE OF THE HYDROGEN BUBBLE CHAMBER MIRABELLE EXPERIMENTAL ASSEMBLY NUMBER SIX. Beauval, J.-J.; Catenne, J.-C.; Desportes, H.; (and others). Bull. Inform. Sci. Tech. (Paris), No. 117, 3-46(July-Aug. 1967). (In French).

The study of the chamber Mirabelle was conducted very experimentally and has given rise to the creation of a number of trial units, the chief of which, Experimental Assembly Number Six ME 6, is a full-scale prototype of the future chamber. The factors responsible for directing the studies along these lines are presented. The means employed to solve the conventional problems of hydrogen bubble chambers are described. In conclusion the future of the chamber and the lines of research it will offer are outlined. (auth)

2423 ARIANE, AUTOMATIC DEVICE FOR THE ANALYSIS OF SPARK CHAMBER PICTURES. Goldwasser, M.; Michau, J.-C.; Mullie, J.; Pichard, B.; Riols, G. Bull. Inform. Sci. Tech. (Paris), No. 117, 47-76(July-Aug. 1967). (In French).

Ariane is an automatic device for the analysis of spark chamber pictures. It is essentially a flying-spot on line with a little computer. Four experiments (about one million pictures) have yet been successfully processed. A new apparatus widely improved is now in progress. (auth)

2424 TRACK DISTORTION IN A STREAMER CHAMBER. Daion, M. I.; Kazurov, V. I.; Krylov, S. A. (Inst. of Physics, Moscow). Prib. Tekh. Eksp., No. 2, 71-3(Mar.-Apr. 1967). (In Russian).

Reports are made on some track distortions in streamer chambers, arising near objects arranged inside the chamber, and on the wall. These data can be of interest in connection with the fact that at the present time experiments using streamer chambers for precise measurements of particle trajectories in a magnetic field and outside it are being discussed. In a series of cases the arrangement inside the chamber was in the form of target, wall, and support. (tr-auth)

2425 PROGRESS REPORT ON FLUX AND SPECTRUM MEASUREMENTS OF THE COSMIC-RAY NEUTRON BACKGROUND. Kastner, Jacob; Oltman, B. G.; Marinelli, L. D. (Argonne National Lab., Ill.). pp 441-8 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Progress on the measurement of the flux and spectra of cosmic-ray-produced neutrons is reported. The design and performance of a twin-scintillation fast-neutron spectrometer and the design and performance of pulse-shape discrimination circuits to discriminate between neutron- and gamma-produced scintillations are presented. (W.H.K.)

Radiation Dosimeters

Refer also to abstract 2119.

2426 (ABS-THH-1037) DIE RICHTUNGSABHAENGIGKEIT DER MESSWERTANZEIGE EINIGER GAMMADOSIMETER. (The Directional Dependence of the Measured Values From Some Gamma Dosimeters). Heinze, K. (Technische Hochschule, Hanover (West Germany). Arbeitsgruppe fuer Bautechnischen Strahlenschutz). Dec. 1966. 13p. (In German). Dep.

In order to obtain concepts on how the orientation of a measurement device or detector in a radiation field can be effected, the directional dependence of the data was investigated for energy and direction distribution of a γ source. A ^{60}Co source with a mean energy of 1.25 MeV was used. The detectors were so arranged that they were intersected by almost parallel beam bundles (monodirectional direction distribution). The measurement results were graphed for Victoreen devices, Vacutronic devices, FH-40-TLS, and Jordan, Model AGB-10KG-SR. (J.S.R.)

2427 (AEEW-R-497) PLASTIC SACHET DOSIMETER CONTAINING LITHIUM FLUORIDE POWDER FOR SURFACE AND FINGER-TIP DOSIMETRY. Peabody, C. O.; Preston, H. E. (Atomic Energy Establishment, Winfrith (England)). Oct. 1967. 18p. Dep. CFSTI. UK 3s. 6d.

A dosimeter is described, consisting of 30 mg of thermoluminescent lithium fluoride powder contained in a plastic sachet. Measurements of its sensitivity for photons and beta rays are presented and discussed. It is shown to provide a convenient, accurate, and reliable method of measuring directly the fingertip radiation dose of workers handling radioactive materials, surface doses from such materials, and doses in general operational and experimental work. (auth)

2428 NATURAL F_2Ca THERMOLUMINESCENT DOSIMETER PROTOTYPE FOR PERSONAL DOSIMETRY. Gonzalez del Campo, Roman (Junta de Energia Nuclear, Madrid). Energ. Nucl. (Madrid), 11: 201-13(May-June 1967). (In Spanish).

Thermoluminescence curves of a natural CaF_2 are given. The dosimeter fabricated with this luminescent material is described. Its sensitivity and its response as a function of the energy and direction of the radiation were measured. The performance of the dosimeter is adequate for the personal dosimetry employed in work that exposes them to x or γ radiation. (J.S.R.)

2429 FERROUS SULFATE DOSIMETRY IN HEAVY WATER. Kumar, S. S.; Faw, R. E. (Kansas State Univ., Manhattan). Nucl. Instrum. Methods, 57: 175-6(Dec. 1967).

A comparison is made of ferric ion yields for the radiolysis of heavy-water and light-water Fricke dosimeter solutions by 14.6 MeV neutrons and ^{60}Co gamma rays. (auth)

2430 STUDY OF THE RECOMBINATION IN HEXANE IONIZATION CHAMBERS IRRADIATED WITH GAMMA RAYS. Giova, A.; Ladu, M.; Pelliccioni, M. (CNEN, Rome). Nucl. Instrum. Methods, 57: 77-81(Dec. 1967).

A theoretical investigation of the influence of columnar and general recombination on the conductivity of n-hexane irradiated with γ-rays from ^{60}Co is presented. A description is given of the measurements carried out with a view to confirming the theory, with the changing of chamber geometry, of the applied electric field and dose rate. The experimental data are in good agreement with theoretical predictions, at least within the limits of the experiment described. Finally, a discussion is made of the importance of the results obtained with a view to developing the application in dosimetry of liquid-dielectric ionization chambers. (auth)

2431 MANGANESE ARSENIC BORATE GLASS DOSIMETER. Bishay, Adli; Arafa, S. (Atomic Energy Establishment, Cairo). Amer. Ceram. Soc. Bull., 46: 1102-5; 1108-9(Nov. 1967).

A manganese arsenic borate glass (SB 257), containing about 74 B_2O_3, 7 Li_2O, 2.4 Al_2O_3, 7 As_2O_3 and 9.6 wt % MnO was tested in the exposure range of from 10^4 to 10^9 rads of gamma radiation and it showed considerable promise as a dosimeter for high-level gamma measurements. It is postulated that a photochemical reaction, in which Mn^{2+} ions are oxidized to Mn^{3+} ions, is responsible for the stable optical absorption band induced by ionizing radiation in this glass at about 2.4 eV (515 mμ). Heating the glass to about 130°C (after irradiation) decreased the contribution of the unstable color centers to the absorption at about 2.4 eV. A relation was obtained between the logarithm of the induced optical density at 2.4 eV (515 mμ) and the logarithm of the total dose. This glass has a wider range of sensitivity and much less fading of the induced optical absorption at 2.4 eV (515 mμ) than most of the existing dosimeter glasses. It has the additional advantage of the low atomic number of most of its constituents, which makes it less dependent on energy distribution of the gamma radiation. (auth)

2432 RADIATION RESPONSE OF LiF AT LOW DOSES. Hendel, W. R. (Univ. of Colorado, Denver). Health Phys., 13: 1235-6(Nov. 1967).

The studies described suggest that thermoluminescence from some batches of TLD-100 LiF may not be directly proportional to dose in the millirad region. When thermoluminescence was plotted as a function of soft tissue millirad dose from 100-kVp, HVT 3.4 mm Al X-rays, a distinct change in slope occurred between 300 and 500 mrads. Annealing the powder a number of times did not influence the shape of the dose-response curve. Similar curves were obtained from exposure to 250-kVp, 2.48 mm Cu X-rays and to ^{60}Co radiation. The possibility that change in slope was due to non-linearity in the readout equipment was eliminated. Standard deviations of millirad luminescence measurements averaged 15.4% of the mean. Results emphasize the need to establish calibration curves for each batch of LiF prior to its application to millirad dose measurements. (UK)

2433 METHOD TO DETERMINE THE PERSONNEL DOSE. I. FILM BADGES. Dresel, Hans (Univ. Freiburg i. B.). Roentgenpraxis 19: 104-13(1966). (In German).

The method used in the German Republic to monitor and evaluate film badges is explained without going into technical details. The evaluation method is based on the use of Cu filters to obtain a film resulting curve and application of correction factors. (J.S.R.)

2434 CLEAR PMMA AS A DOSIMETER IN THE MIXED γ,n FIELD OF A REACTOR. Kostalas, H. A. (NRC, Democritus, Athens). Int. J. Appl. Radiat. Isotop., 18: 783-5(Nov. 1967).

The use of undyed PMMA (polymethyl methacrylate) as a dosimeter for the megarad range is discussed. The possibility of using it in the mixed field of an operating reactor to distinguish between the doses due to neutrons and those due to gamma radiation was examined. (auth)

2435 POSSIBILITIES OF APPLICATION FOR THE AQUEOUS SOLUTION OF KI AS A CHEMICAL DOSIMETER. Fiti, Maria; Tudor, Lucia (Institut de Physique Atomique, Bucharest). Rev. Roum. Phys., 12: 583-8(1967). (In French).

Solutions of potassium iodide in the presence of certain buffer agents were irradiated by gamma rays from ^{60}Co and by 400-keV electrons from a Van de Graaff accelerator. The study of the oxidation of I^- in various conditions (the effects of absorbed dose, temperature, radiation intensity, pH, and the initial concentration of the solution) showed that a 0.1 M KI solution in the presence of 0.1 M KH_2PO_4 can be used as a chemical dosimeter having a base of $G(I_2) = 0.48 \pm 0.02$ molecules/100 eV, for dose measurements between $2(10)^4$ and $2(10)^6$ r/ml. The possibilities of using this dosimetric device and the radiolysis mechanism in the presence of buffering agents were considered. (tr-auth)

2436 ELECTRON BEAM DOSIMETRY USING THE RADIATION INDUCED FLUORESCENCE OF POLYETHYLENE. Radovsky, D. A. (IBM Corp., N Y.); Brumberger, H. Nature (London), 216: 469-70(Nov. 4, 1967).

A study is described on the effects of high energy electron radiation on the properties of polyethylene, with particular regard to fluorescence. It was observed that the fluorescence intensity, excited by mercury lamp illumination of a simple previously electron beam irradiated, increased linearly with dose over the range 0 to 40 MR. The fluorescence was persistent, reproducible, and easily measured, and thus may be useful for dosimetry applications. In the experimental work a variety of polyethylene samples were examined, with different density and molecular weight values, with and without anti-oxidant. Irradiation doses ranged from 0 to 160 MR, in 10 MR steps, and all irradiations were made in air at room temperature, at 10 MR per pass. The fluorescence spectra are reproduced, using a Cary 15 spectrophotometer with fluorescence attachment. The principal excitation wavelengths were in the regions of 3120 and 3330 Å, with lesser amounts at 3650 and 2537 Å. The wavelength of the fluorescence emission spectrum selected for measurement was 4470 Å. Anti-oxidants did not affect linearity, but appeared to have some effect on intensity. The fluorescence persisted for at least 3 years after irradiation. The effect of heat was to quench fluorescence. With regard to the fluorescence mechanism, it is possible that the carbonyl group is involved. (UK)

2437 TISSUE DOSE DUE TO NEUTRONS OF COSMIC-RAY ORIGIN. Hill, C. R.; Woodhead, D. S. (Royal Cancer Hospital, Surrey, Eng.). pp49-61 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

Some of the apparent difficulties involved in estimating tissue dose to man due to cosmic neutrons are discussed. The Hurst tissue-equivalent proportional detector was investigated as a means of measuring both the absolute levels of cosmic neutron dose to man and its possible variations. The instrument was used

to measure cosmic neutron dose and it appears that the actual dose rates may be appreciably less then anticipated. (B.G.D.)

Radiometric Instruments

Refer also to abstract 2287.

2438 BETA-RAY SLIVER GRAIN GAGE APPLIED TO COTTON SPINNING MACHINE. Katagiri, Michio; Takahara, Hisao (Yokogawa Electric Works Ltd., Japan). Radioisotopes (Tokyo), 16: 577-82(Nov. 1967). (In Japanese).

Textile industry is still behind in application of automatic control of sliver weight by cotton spinning gaging technique, because of difficulty in realizing reliable detecting instruments. Several methods of gaging such as by capacitance measurement, optical absorption, airmicrometer or mechanical feeler like Autoleveller have been developed for on-line measurement and control, but they did not result in success. In recent years, some advantages have been discussed for application of beta-ray radiation gaging techniques to sliver weight measurement, and despite the basic physical possibility no commercial type of this system has yet been realized, as its reliability, cost and safety requirement of health are not satisfied. A new type of detector having sliver guide unit combined with windows of chamber and radiation source was investigated. This sliver guide made of aluminum foil of 0.03 mm has an air ejector at the input, by which a broken end of sliver can be easily guided in the hole when it should be inserted. Sliver can run away in the guide hole with loose contact to the guide wall so that it always sweeps away much flying cotton fiber which causes gage drift if it remains on the wall, and can avoid static charge effect as the running sliver is grounded through the wall. No error is made by position change of running sliver as it is well positioned by the guide and radiation not passing through sliver does not fall into the chamber by this detector arrangement. The dynamic weight of sliver while running must be compared with the static weight which is widely used in conventional quality control of sliver, as the dynamic weight depends on the drawing condition. The effect of drawing tension and the appearance of running sliver in the guide were considered. The experiments show good correlation between them using some constant determined by the speed of drawing. This sliver grain gage has ^{204}Tl of 15 mCi as a source and the all solid state electrometer using variable capacitance diode and gives the span of ±10% for 100 grains as a minimum range. The dynamic weight gives an accuracy within ±0.2% for 400 grains on the actual application to the drawing machine. The test was made either for a long continuous operation more than a month or immediately after switching on. This beta-ray sliver grain gage will be used as the detector of cotton spinning machine controller. (auth)

2439 ^{63}Ni FOIL IN A STANDARD CONCENTRIC CELL FOR ELECTRON-CAPTURE DETECTION. Ahren, A. W.; Phillips, W. F. (Campbell Inst. for Food Research, Camden, N. J.). J. Agr. Food Chem., 15: 657-60(July-Aug. 1967).

Concentric design electron-capture detectors were converted, using ^{63}Ni, for operation at 300°C in pesticide residue analyses, and the characteristics and reliability were evaluated. This study was conducted using a Barber-Colman Model 10 dual column gas chromatograph originally equipped with high-temperature ^{226}Ra β ionization detectors and 50-mV recorders. After several years of operation at high temperature and low and high voltages, these detectors were reconditioned and converted to ^{63}Ni. The physical form of this isotope is pure ^{63}Ni electroplated to a stainless steel foil. This detector was fitted with a foil containing 13.5 mCi of ^{63}Ni. After more than 1 yr of continuous operation at 300°C, there was no significant change in standing current and no radioactive leakage was detected. This high temperature ^{63}Ni detector provided a continuously operable analytical system of high reliability which requires a minimum of maintenance. (BBB)

2440 DOUBLE-BEAMED HOLE GAMMA-GAMMA DENSIMETER. Varvarin, G. B.; Kuznetsov, G. A.; Filippov, E. M. (Inst of Geology and Geophysics, Novosibirsk, USSR). Geol. Geofiz., No. 6, 89-97(June 1967). (In Russian).

New deep-seated gamma-gamma logging instrument for determination of rock densities in hole sections is described. This instrument allows exclusion of the influence of near hole zone (cavern, clay crust etc.). The instrument described does not need the application of pressing equipment which is different from up to date hole densimeters and allows recording in units of rock density in hole sections. This instrument has undergone testing and shows satisfactory results. (auth)

2441 AUTOMATIC CONTROL AND REGULATION OF THE HUMIDITY OF SINTERING CHARGE. Bezinskii, N. S.; Betin, Yu. P.; Verkhovskii, B. I.; Emelyanov, V. L.; (and others). Stal, No. 12, 1086-7(Dec. 1966).

A neutron hygrometer was developed and successfully used in automatically controlling the humidity of a sinter charge. The hygrometer consists of two separates blocks: a meter, placed in direct proximity to the object being controlled and an electron recording device, positioned on the control panel. The hygrometer uses a Pu-Be source of fast neutrons with a capacity of $4-10^5$ neutrons/sec. The neutron hygrometer measures charge humidity at the outlet of one of the mixing drums, therefore a portion of the charge from the drum is fed into a special device. Use of the hygrometer makes it possible to maintain charge at a specified humidity to an accuracy of 0.3%. A high gas permeability and the required sintering rate are thus maintained. Quantity of return has been decreased and sinter productivity has been increased. (Rev. Met. Lit.)

2442 TORQUE MEASUREMENT. II. Myers, H. (John Dalton Coll. of Tech., Manchester, Eng.). Instrum. Pract., 21: 1028-33(Nov. 1967).

A description is included of the application of radioisotopes as signal inputs to electric dynamic torquemeters. Advantages are that no power supply is required and that the instrument is unaffected by variation in pressure and temperature. The response of the instrument is also independent of changes in speed of rotation, and sensitivity and accuracy are high. Special couplings are unnecessary, as the instrument slides on to the shaft. Calibration is simple. The output signal from the radiation detector can be fed to a recorder or dial gauge, or the particles can be counted with, for example, a scalar. The radiation passes through an aperture into the detector, the amount received by the latter depending on aperture size, which is directly proportional to applied torque, providing the strain is within the elastic limit of the material. (UK)

2443 REMOTE CONTROL AND PULSE TRANSMISSION SYSTEM FOR THE MULTICOUNTER DIRECTIONAL PROBE. Baranski, Leslaw; Korbel, Kazimierz. Nukleonika, 12: 553-7(1967). (In Polish).

A system of remote control of the detecting channels and counter pulse transmission is described. It was worked out for the multicounter directional probe used in the measurements of the direction and flow velocity of water in the natural reservoirs. A bidirectional junction between the probe and the surface unit was provided by means of a single coaxial cable. (auth)

2444 TEN YEARS OF NUCLEAR RESEARCH IN STEELMAKING OPERATIONS. Stone, Leonard R. Blast Furnace Steel Plant, 54: 1121-32(Dec. 1966).

Research on the use of nuclear reactions in the steel industry has led to the extended use of commercial nuclear gaging devices and to the development of: a nuclear level gaging system to determine the stock level inside the blast furnace; a nuclear system for aligning coke oven machinery correctly for the coke pushing operation, and a noncontact double beam nuclear gaging system to measure the moisture content of conveyor-fed raw materials such as ore, coke, coal, and sinter feed. Process analysis with nuclear tracers is also very important, as shown by work with short-life tracers to study vacuum degassing operations. (Rev. Met. Lit.)

Miscellaneous Instruments and Components

Refer also to abstracts 2267, 2275, 2318, 2502, and 2645.

2445 (AERE-R-5529) AN 880 KILOBIT/SEC DATA TRANSMISSION SYSTEM FOR COMPUTER-TO-COMPUTER COMMUNICATION. Austin, J. S.; Barnes, R. C. M.; Fergus, P. J. B. (Atomic Energy Research Establishment, Harwell (England)). July 1967. 13p. Dep. CFSTI. UK 2s. 6d.

A data transmission system is being developed for communication between the AERE central computer complex and remote computers serving experiments. The minimum data transfer rate is 88 kilobytes/sec. for 8-bit bytes, or 63 kilobytes/sec for 12-bit bytes. Each data link operates over two pairs of wires in the multipair telephone cables which are being installed for remote Teletype terminals of the central computer. (auth)

2446 (BNWL-399) MICROWAVE MEASUREMENT OF HIGH TEMPERATURES WITHIN NUCLEAR REACTORS. Interim Report. Billeter, T. R.; Brown, D. P. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Oct. 1967. Contract AT(45-1)-1830. 25p. Dep. CFSTI.

Two microwave methods of measuring nuclear reactor in-core temperatures are proposed. Measurements by the first of the two methods investigated, the active system, are accomplished by re-

lating the frequency shift of a microwave cavity to the temperature of its surroundings. In experimental tests, the measurement sensitivity of this method proved to be 300 kHz/°C for temperatures to 1000°C. Because the measurement of frequency to an accuracy of one part in 10^6 is possible with ease, a theoretical precision of measuring temperature is ±0.05°C. This is adequate to satisfy temperature sensor criteria of many recently constructed reactors. Response of the temperature sensor was not determined during the initial experiments; however, the sensor accurately monitored a rate-of-increase of temperature of 30°C/min. Stability of the required instrumentation proved excellent, and repeatability of measurements was only slightly affected by oxidation of the copper waveguide at the elevated temperature of 1000°C. Experimental work with the second method, a passive measurement system, requires employment of a microwave radiometer. Theoretical temperature sensitivity of the instrumentation indicates that a 1°C change at the sensor will provide a 0.45°C temperature change at the radiometer. Both temperature measurement methods require a waveguide to be inserted within a high-temperature and possibly corrosive environment. Methods which would retard the damaging effects of an oxidizing atmosphere are suggested in this report. Although preliminary in nature, experimental results indicate that microwave methods of monitoring nuclear reactor in-core temperatures during normal operation are adequately sensitive, and should materially reduce problems associated with other types of temperature sensors. (auth)

2447 (CEA-R-3181) CALORIMETRE DIFFERENTIEL A PUISSANCE COMPENSEE -196°C/400°C. (Compensated-Power Differential Calorimeter for -196 to 400°C). Bonjour, Emmanuel; Pierre, Jacques; Agagliate, Serge; Bertrand, Pierre; Faivre, Jean; Lagnier, Robert (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). June 1967. 59p. (In French). Dep.

A differential calorimetric device of original design is described. It allows direct measurements of thermal effects (adsorption or release) during a linear rise of temperature. The self compensated power method which is applied by means of a very sensitive control system, gives a direct value of the differential heat capacity between the sample and a dummy of it. The detection threshold is about ±100 to ±250 microwatts. The applications of the colorimeter are generally measurements of enthalpy changes of massive or powdered samples, measurements of Wigner energy after low temperature irradiation (77°K), and measurements of energy release in low temperature (77°K) cold worked metals. (auth)

2448 (CONF-671102-30) NEUTRONICS INSTRUMENTATION FOR ROVER REACTORS. McFerrin, D. N.; Perry, R. T. Jr. (EG and G, Inc., Las Vegas, Nev.). [1962]. Contract AT(29-1)-1183. 17p. Dep. CFSTI.

From 15th Conference on Remote Systems Technology and Atom Fair, Chicago, Ill.

Instrumentation for control and safety systems for Rover reactors is discussed. Reactor control is based on temperature and flow rates, and the solid-state monitoring instruments and circuitry are briefly described. (W.H.K.)

2449 (INP-560/PS) VERSATILE AND MULTIPURPOSE AUTOMATIC PLOTTING SYSTEM. Zaleski, Tadeusz; Olejarczyk, Wiktor (Institute of Nuclear Physics, Krakow (Poland)). July 1967. 8p. Dep.

A plotting system based on a multichannel eKBT6EN type strip chart compensating recorder is described. The system consists of a digital-to-analog converter, a programmer, and an eKBT6EN type recorder. The range of its application is very wide, e.g.: plotting of curves from multichannel analyzers and various types of spectrometers. The accuracy is better than 1%. The maximum printing speed is 1 channel per second. It can also be used as part of a system which is plotting curves from a punched tape or, after connection to a simple control board, for hand-plotting. (auth)

2450 (INR-806/III/E) ANALIZA SZYBKICH UKLADOW KOINCYDENCJI DWU- I WIELOKROTNYCH PRZY UWZGLEDNIENIU STATYSTYCZNEGO ROZRZUTU OPOZNIEN. (Analysis of Fast Two- and Multifold Coincidence Circuits Influenced by Statistical Time Spreads). Kalisz, Jozef (Institute of Nuclear Research, Warsaw (Poland)). 1967. 100p. (In Polish). Dep. Thesis.

The problems involved in determining statistical parameters of coincidence circuits, resolving time, jitter breadths, and efficiency are discussed. Analysis is carried out at the assumption of Gaussian jitter distributions. Two methods, slope method and point method, are presented allowing determination of these parameters if a single empirical coincidence curve is given. Utilizing the digital computer allowed for obtaining the tables and clear diagrams. The methods were presented for double and triple coincidence circuits and next generalized for multifold coincidence circuits. The concepts of coincidence surface and coincidence hypersurface are discussed. The use of the presented theory was illustrated by some numerical examples. (auth)

2451 (JAERI-1142) ANEMOMETRIC CHARACTERISTICS OF SEMICONDUCTOR FLOWMETER. Okamoto, Yoshizo; Hanawa, Juichi (Japan Atomic Energy Research Inst., Tokyo). May 1967. 13p. (In Japanese). Dep.

The annemometric performance of a semiconductor flowmeter has been improved by use of a spherical head in the center of which a thermistor particle is inserted. Stagnation, standard flow, and free flow tests were made, and the relation between the head release and flow velocity was obtained. The results of experiments were expressed by a simple correlation of Nusselt number and Reynolds number. The relation between an inclined angle and the Nu number was also obtained when the channel axis of the head was inclined to the flow direction. (auth)

2452 (JINR-P9-3527) UPRAVLENIE CHASTOTI AVTODINA V SLEDYASHCHEM ZA POLEM YaMR MAGNITOMETRE. (Control of the Autodyne Frequency in a Self-Locking NMR Magnetometer). Lachinov, V. M. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1967. 11p. (In Russian). Dep.

A scheme of an autodyne detector used in a completely automatized NMR magnetometer is presented. An arrangement is designed using varicaps to control the autodyne frequency that provided the conditions close to optimal for the servomechanism. (auth)

2453 (ORNL-IIC-10(Vol.1), pp 282-97) A SULFUR DENSITOMETER FOR SCANNING PAPER ELECTROPHORETIC STRIPS FOR SULFUR CONTENT OF PROTEIN FRACTIONS. Natelson, Samuel (Michael Reese Hospital, Chicago, Ill.).

Electrophoresis for serum proteins is carried out in the conventional manner. The sulfur emission, resulting from exposure to an x-ray field, is then monitored with the rate meter of an x-ray spectrometer whose output is fed to a recorder; protein distribution is estimated with a densitometer. Total protein and total sulfur in the original serum are then determined. (auth)

2454 (ORNL-TM-1638(Pt.12)) NUCLEAR INSTRUMENT MODULE MAINTENANCE MANUAL. PART 12. OR GATE, ORNL MODEL Q-2612. Anderson, J. L. (Oak Ridge National Lab., Tenn.). Sept. 19, 1967. Contract W-7405-eng-26. 13p. Dep. CFSTI.

The circuit, application, maintenance procedures, and acceptance tests for a multiple input logical OR Gate are described. The circuit is constructed in a "1-unit" module of the ORNL Modular Reactor Instrumentation series Q-2600, and is intended for use in safety systems of reactors employing this series of instruments. (auth)

2455 (RHEL/R-133) INTRODUCTION TO TRANSISTOR CIRCUIT TECHNIQUES. Herbst, L. J. (Rutherford High Energy Lab., Chilton (England)). June 1967. 126p. Dep. CFSTI. UK 15s. 0d.

The notes prepared for a course of ten lectures held at Reading College of Technology in the autumn of 1966 are presented. The lectures deal with low and high frequency amplification, and also switching techniques, where the emphasis is on integrated circuit practice. The final lectures contain brief introductions to field effect transitors and digital integrated circuits. The notes remain in their original form but a number of worked examples have been added at the end. (auth)

2456 (UCRL-17715) AUTOMATIC CONTROL SYSTEM FOR DETECTION OF NUCLEAR MAGNETIC RESONANCE. Wang, C. C. (California Univ., Berkeley. Lawrence Radiation Lab.). Aug. 3, 1967. Contract W-7405-eng-48. 25p. Dep. CFSTI.

An automatic control system for detection of the nuclear magnetic resonance is described. The system is the combination of the commercially available instruments and the modular units developed in the Lab. The frequency of interest is anywhere between 100 MHz and 900 MHz. The range of the frequency sweeping is determined by the sample under observation, which is seldom over 100 MHz. The accuracy of the frequency repetition is within 100 kHz. (auth)

2457 (UCRL-70547) ON-LINE DATA COLLECTION BY COMPUTER IN A MULTI-EXPERIMENT BIOMEDICAL GAMMA SPECTROSCOPY SYSTEM. Uber, Donald C. (California Univ., Livermore. Lawrence Radiation Lab.). Oct. 10, 1967. Contract W-7405-eng-48. 4p. (CONF-671026-6). Dep. CFSTI.

From 14th Nuclear Science Symposium, Los Angeles, Calif.

A system is described in which a PDP-8 computer collects data on-line from up to twenty high-resolution pulse height analyzers

used in biomedical gamma spectroscopy counting. The computer takes data directly from the analog-to-digital converters and stores it unsorted on IBM magnetic tape. These tapes are sorted and analyzed off-line on larger computers. An oscilloscope provides two modes of display of the spectral data being collected. Through another interface, the PDP-8 accepts complete spectra dumped from the memories of other analyzers operating off-line. (auth)

2458 POSSIBLE SIGNIFICANCE OF THE FLUORESCENCE CORRECTION IN ELECTRON-PROBE MICROANALYSIS OF LIGHT ELEMENTS. Openshaw, I. K. (Associated Electrical Industries Ltd., Manchester, Eng.); Pearce, R. J.; Jeffery, B. M. Brit. J. Appl. Phys., 18: 1004-8(July 1967).

Carbon analysis using an electron-probe microanalyzer was carried out on a duplex silicon carbide-uranium dicarbide nuclear fuel. The results are discussed in relation to various correction procedures and it is shown that they may be explained by postulating either a very low value for the mass-absorption coefficient of carbon K x rays in uranium or fluorescence of the carbon K radiation by uranium N radiation. (auth) (UK)

2459 DEVELOPMENT OF A TIME-OF-FLIGHT MASS SPECTROMETER CAPABLE OF OPERATING AT 10^{-8} TORR. Zvenigorosky, A. (Laboratoire de Physique Experimentale, Toulouse). Vide, 22: 196-202(July-Aug. 1967). (In French).

A time-of-flight mass spectrometer was constructed which is fully demountable and contained only degassing materials. The physical design is quite flexible. The problem of modifying the device for specific purposes is simplified. The instrument is capable of reaching a pressure of 10^{-8} torr. The resolution power is 40. (auth)

2460 TEMPERATURE STABILIZATION OF A CURRENT GENERATOR. Papadopoulos, L. (Democritus Nuclear Research Center, Athens). Nucl. Instrum. Methods, 57: 74-6 (Dec. 1967).

The precision of nuclear measurements often depends on the level stability of the discrimination stages. Level variations occur either due to variations of the trigger element characteristics of a stage or to the variations of the biasing dc current of the stage. A dc current generator supplying a constant current independent of temperature variations is described. (auth)

2461 MEASUREMENTS ON THE DISTRIBUTION OF THE ELECTRONIC TRANSMISSION TIME IN THE PHOTOMULTIPLIER VALVO 58 AVP. Hasselbach, F.; Mack, G. (Univ., Tuebingen, Ger.). Nucl. Instrum. Methods, 57: 121-4(Dec. 1967). (In German).

For the photomultiplier Valvo 58 AVP the time spread behavior has been measured with a traveling wave oscilloscope. The electron optical input system and the dynode system have been investigated separately. Risetimes of single electron pulses or risetimes and times of arrival of anode pulses produced by a light flash lamp which illuminated the cathode partially or as a whole have been measured. By varying the potentials at different electrodes conditions for optimum time spread behavior were found. (auth)

2462 INSTABILITY AND DECOUPLING IN NUCLEAR ELECTRONICS. Whittaker, J. K. (National Bureau of Standards, Washington D. C.). Nucl. Instrum. Methods, 57: 156(Dec. 1967).

The instabilities which can occur in semiconductor electronics and the necessary decoupling to remove these instabilities and their effects are discussed, with particular reference to the present concept of modular electronic systems. (auth)

2463 AUTOMATIC GAIN CONTROL OF A PHOTOMULTIPLIER AND RELATIVE ELECTRONIC LINEAR CHAIN. Bacci, C. (Istituto Nazionale di Fisica Nucleare, Rome); Bidoli, V.; Baldini-Celio, R. Nucl. Instrum. Methods, 57: 100-4(Dec. 1967).

An automatic gain control system for a photomultiplier and its electronic linear chain, which can be used in the presence of a high radiation level, is described. (auth)

2464 RING COUNTER FOR FAST DECIMAL SCALERS. Baldinger, E.; Simmen, A. (Univ. of Basel). Nucl. Instrum. Methods, 57: 141-6(Dec. 1967).

A ring counter with a resolution of 300 Mc is described. The circuit is reliable because of the counting code. A prototype of a decade counter (pulse shaper and flip-flop followed by the ring counter) has a resolution of 500 Mc. (auth)

2465 A HIGH EFFICIENCY EVENT SELECTOR FOR AN ON-LINE COMPUTER. Murray, G. L.; Macefield, B. E. F. (Oxford Univ.). Nucl. Instrum. Methods, 57: 37-42(Dec. 1967).

A high efficiency event selector constructed from digital logic modules is described and its performance compared to that of an equivalent software system. (auth)

2466 INVESTIGATION OF CHARGE EXCHANGE IN ION SOURCES. Holley, W. L.; Skidmore, M. R.; Lee, J. V. (Oak Ridge National Lab., Tenn.). Contract W-7405-eng-26 Nucl. Instrum. Methods, 57: 13-16(Dec. 1967). (ORNL-P-2748).

Charge exchange phenomena in a calutron ion source were investigated using a reflecting grating spectrograph. Doppler shifts observed in ionized calcium spectra from the source region of an electromagnetic isotope separator correspond to ion velocities of up to $\sim 7 \times 10^7$ cm/sec in the accelerating region. These maximum velocities are greater than would be expected from the potential difference between the electrodes and are due to the charge exchange of doubly charged ions after being partially or fully accelerated. High velocity neutral calcium particles due to charge exchange of singly charged ions are also observed. These charge exchange phenomena in the accelerating region are probably responsible for a part of the isotopic contamination present in collected isotopes. In an alternative approach, Aston bands resulting from charge exchange phenomena were studied directly in the isotope separator. (auth)

2467 NEW METHOD TO MEASURE NEUTRON POLARIZATIONS WITH ENERGY DISCRIMINATION. Efken, B.; Hilscher, D.; Scheer, J. A.; Schroeder, W. U. (Hahn-Meitner-Institut fuer Kernforschung, Berlin). Nucl. Instrum. Methods, 57: 1-5(Dec. 1967).

A new type of polarimeter for fast neutrons is described. The asymmetry in n-α scattering taking place between the plates of a helium-filled parallel plate avalanche counter is determined by measuring the pulse-height distribution caused by the recoil α-particles. Due to the mechanism of avalanche formation the pulse height depends strongly on the recoil direction, therefore the distributions differ for left and right scattering. The fast rising avalanche pulse allows the determination of neutron energies by time-of-flight measurements enabling one to measure polarizations for various neutron groups simultaneously. (auth)

2468 REMOTE BALANCE FOR ACCURATE WEIGHING IN HIGH RADIATION ENVIRONMENT. Eggenberger, D. N.; Shuck, A. B. (Argonne National Lab., Ill.). Nucl. Instrum. Methods, 57: 89-92(Dec. 1967).

A balance used at Experimental Breeder Reactor II to weigh radioactive fuel pieces is described. The weighing and handling must be done in a shielded cave by remote control. A commercial balance was modified for this use and outfitted with electronic controls and digital readout. The beam balance has a poise weight positioned by a precision screw which is driven by a stepping motor. The remote readout is coupled to a mechanical counter driven by another stepping motor which operates synchronously with the balance motor. The balance is accurate to ±2 g over a range from 100 to 18,000 g and has been in operation for over a year at gamma radiation levels as high as 10^6 R/h. (auth)

2469 CALUTRON EXPERIMENTS WITH MILLIGRAM QUANTITIES OF CHARGE MATERIAL. Underwood, J. N.; Love, L. O.; Prater, W. K.; Scheitlin, F. M. (Oak Ridge National Lab., Tenn.). Contract W-7405-eng-26. Nucl. Instrum. Methods, 57: 17-21(Dec. 1967). (ORNL-P-3134).

An ORNL electromagnetic isotope separator (calutron) has been operated with milligram amounts of uranium charge material. A series of nine experimental runs using 1 to 50 mg of charge (material) achieved process efficiencies ranging from 1 to 13%. In one of the experimental runs, ^{235}U was enriched from 0.72 (normal abundance) to 94.3% in a single pass. (auth)

2470 CALCULATION OF THE SHAPE OF THE MASS SPECTRUM PULSE FROM A DYNAMIC QUADRUPOLE MASS SPECTROMETER. Slobodenyuk, G. I. Zh. Tekh. Fiz., 37: 1535-9(Aug. 1967). (In Russian).

The shape of the pulse from a dynamic quadrupole mass spectrometer of the type discussed by W. Paul, H. Reinhard, and U. von Zahn (J. Phys., 152, 145, 1958) was calculated. In this instrument both constant and alternating potentials are applied to the plates of a quadrupole capacitor. The two transverse Cartesian coordinates of an ion moving through the field of this capacitor satisfy Mathieu differential equations in the time and the instrument passes ions whose trajectories correspond to periodic solutions of these equations. The current through the exit aperture was calculated as a function of the parameters of the spectrometer under the assumptions that the ion beam incident on the entrance aperture is directed parallel to the axis of the instrument, has zero spread, and has a constant current density over the area of the aperture. The calculations were performed for a one-parameter family of entrance apertures ranging in shape from four-pronged stars with the prongs parallel to the transverse axes of the quadrupole capacitor through a series of rhombi (including squares) to stars with the prongs at 45° to the transverse

axes. The result is given in analytic form, and curves calculated for particular parameter values are presented and discussed. The results represent a first approximation to the relations among the height and shape of the output pulse, the size and shape of the entrance aperture, the ion mass, and the resolving power and other parameters of the instrument, and should be useful for design purposes. (ATD)

2471 MECHANICAL PROBLEMS IN DEVELOPMENT OF IMBEDDED ELECTRICAL CONNECTORS FOR INSTRUMENTED FUEL ELEMENTS IN NUCLEAR REACTORS. Cesari, Franco (CNEN, Rome). Ing. Mecc., 14: No. 10, 1-11(1965). (In Italian). (RT/ING(66)2).

The installation of an electric connector in the upper part of a fuel element of an organic-cooled nuclear reactor is described. The male plug of the connector is placed in the lower part of the rod inlet and the female plug is placed in the upper part of the element. The precautions necessary to assure an adequate contact of connectors in order to assure a good electric contact between the male and female parts are described. The individual parts of the components are also described and the operation is illustrated. (tr-auth)

2472 CONTROL SEQUENCE SYSTEM FOR AUTOMATIC ACTIVATION ANALYSIS. Koziorowski, J.; Ostachowicz, J. Nukleonika, 12: 559-62(1967). (In Polish).

The construction and operation of the sequence system for time programming of the particular operations in automatic activation analysis was described. This system allows to control the times of the particular operations in the range of 0-60,000 sec. Practically, the last two operations, i.e., the decay and the measurement of the induced activity, can be repeated as many times as it is necessary. It is also possible to repeat automatically the cycle of the samples analysis according to the established program. The sequence system is a relay system based on the TCeF4PE numerators manufactured by Sodeco. (auth)

2473 TEMPERATURE REGULATORS FOR SAMPLES USED IN NEUTRON SCATTERING EXPERIMENTS. Tarina, E.; Timis, P. (Institut de Physique Atomique, Bucharest). Rev. Roum. Phys., 12: 545-9(1967). (In French).

Two devices for controlling the temperature of samples used in neutron scattering studies are presented. These devices control the reaction using a heat regulating element placed between the energy source and the heating element. The transducers for temperature measurements are a thermocouple which operates at 100 to 1000°C and a thermistor which operates at 0 to 70°C. Stabilities of ±0.04 and ±0.01°C are obtained, respectively. (tr-auth)

2474 INDUCTIVE ENERGY STORAGE SYSTEM USING IGNITRON SWITCHING. Simon, E.; Bronner, G. (Princeton Univ., N. J.). Contract AT(30-1)-1238. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-14: No. 5, 33-42(Oct. 1967).

Previous work in the field of inductive energy storage and control is described. The need for a fast, reliable switch for the control of such systems is pointed out. A new inductive-energy storage switching system that fulfills this need is described. The new system utilizes an ignitron bridge circuit and a capacitor to invert from the unidirectional current of an inductive source to an alternating voltage of triangular waveform. The alternating voltage is used to charge and periodically recharge a small capacitor. This capacitor in its turn supplies energy to the load. Thus, by the use of two capacitors, whose maximum stored energy is very small compared to the total energy to be transferred, the stored energy may be transferred to the load in discrete parcels. The disassociation of storage and load circuit allows the transfer of all stored energy to the load, with the exception of the usual resistive energy loss imparted by circuit elements, a quantity that can be kept small. Therefore, the energy efficiency is higher than heretofore attained by inductive energy storage systems. Current relations in the circuit during charge and during transfer are described, and optimization of circuit parameters is discussed briefly. (auth)

2475 MIXING APPARATUS. Fortin, Marcel; Fradin, Jean; Raggenbass, Andre (to Commissariat a l'Energie Atomique). British Patent 1,090,579. Nov. 8, 1967. Priority date Oct. 9, 1964, France.

Specifications for a remote-controlled mixing apparatus for radioactive materials are presented. The apparatus consists of a container and an agitator mounted on coaxial drive shafts constructed for various modes of operation. (W.H.K.)

2476 METHOD OF SAMPLING GAS-BORNE MATTER BY FILTRATION AND DEVICE FOR THE APPLICATION OF SAID METHOD. Jouault, Pierre (to Commissariat a l'Energie Atomique). British Patent 1,089,628. Nov. 1, 1967. Priority date Nov. 30, 1964, France.

Equipment designed for obtaining samples of radioactive gas-borne matter is described. The equipment consists of a volumetric pump attached to a cylindrical chamber which is closed by a filter. Between the filter and the wall of the chamber a porous sintered bronze disk is located. Air sucked by the pump passes through the filter which collects the radioactive particles. Pressure across the filter drops because of the deposited particles. In order to maintain a constant air flow, the pressure drop across the disk is maintained in the opposite sense to the variation of the pressure drop across the filter. This is accomplished by impregnating the porous disk with a viscous fluid. The quantity of viscous fluid is reduced and the sum of the pressure drops can be maintained constant. (F.S.)

Radiation Effects on Instruments and Instrument Components

Refer also to abstract 3193.

2477 INVESTIGATION OF RADIATION STABILITY OF SILICON SEMICONDUCTOR DETECTORS DURING IRRADIATION WITH 2.3-MeV PROTONS. Antronov, A. E.; Brykina, L. S.; Vaganov, P. A.; Zhampa, A.; Kolalis, R. P.; Landsman, A. P.; Orlov, B. N.; Fedoseeva, O. P.; Chubinskii, O. V. Kosm. Issled., 5: 622-32(July-Aug. 1967). (In Russian).

The results of the investigation of the effect of protons at 2.3 MeV, accelerated in the cyclotron, on silicon semiconductor detectors were reported. The possibility of using semiconductor detectors as spectrometric devices during extended work under conditions of intense proton radiation of low energy was investigated. For 10 detectors (7 lithium diffusion-drifted and 3 surface barrier detectors) the inverse current, energy resolution, and pulse amplitude from particles were measured as functions of the perturbations to the capacity. The irradiation was carried out in successive steps from integral doses of 10^{10} to 10^{13} or 10^{14} protons/cm^2. The characteristics of the detectors were measured with respect to the irradiation and after each of the steps. The sensitivity found to irradiation indicated the magnitude of the capacity; substantial changes began after doses of 10^{11} protons/cm^2. The sharp deterioration of the spectrometric properties was observed at integral currents of the order of 10^{12} protons/cm^2 (energy resolution was decreased 2 times and the pulse amplitude decreased 10%), but surface-barrier detectors increased their property of endurance at room temperature during several days. Analogous "annealing" in some cases was observed in diffusion-drifted detectors. At doses of the order of 10^{13} protons/cm^2 irreversible processes occurred (detectors lose their spectrometric property). (tr-auth)

2478 PERMANENT RADIATION DAMAGE EFFECTS IN NARROW-BASE PNPN DEVICES. Wilson, D. K.; Lee, H. S. (Bell Telephone Labs., Inc., Whippany, N. J.). Contract AF 19 (628)-4157. IEEE (Inst. Elec. Electron. Eng.), Trans. Nucl. Sci., NS-14: No. 5, 15-32(Oct. 1967).

The effects of fast-neutron radiation damage in narrow-base PNPN devices were measured and compared with a simple, one-dimensional theory for PNPN devices, based on the work of Kuz'min. The limitations of a PNPN device in a radiation environment are primarily determined by the increased forward "on" voltage. A reasonably good fit of observed and calculated "on" voltages for a variety of PNPN's was obtained using a silicon lifetime damage constant of $\approx 10^{6}$ sec-N/cm^2. Design considerations for radiation-resistant PNPN's are discussed, and devices capable of operating after exposure to more than 10^{15} neutrons/cm^2 are described. PNPN's are shown to be superior to bipolar transistors as power switches in a radiation environment. (auth)

LIFE SCIENCES

Biochemistry, Physiology, and Molecular Biology

Refer also to abstracts 2502–2504, 2508, 2509, 2511, 2525, 2534, and 2537.

2479 (BNWL-SA-1252) PROPERTIES OF RADIONUCLIDES IN TISSUES: A NEW LOOK AT SOME OLD PROBLEMS. Thompson, Roy C. (Battelle-Northwest, Richland Wash. Pacific Northwest Lab.). May 8, 1967. Contract AT(45-1)-1830. 7p. (CONF-670521–6). Dep. CFSTI.

From Symposium on Diagnosis and Treatment of Deposited Radionuclides, Richland, Wash.

A brief review of recent studies is presented on the following aspects of radioisotopes: deposition and metabolism of plutonium in liver and bone of man, beagles, and miniature swine; inhalation toxicity and pulmonary lymph node deposition of plutonium; leukemia and osteogenic sarcoma in miniature swine following ingestion of ^{90}Sr; and excretion of ^{90}Sr by rats. (H.L.W.)

2480 (ORNL-IIC-10(Vol.1), pp 233-47) MOESSBAUER SPECTROSCOPIC STUDIES OF HEMOGLOBIN. Grant, R. W. (North American Aviation, Inc., Thousand Oaks, Calif. Science Center).

The Mössbauer effect in ^{57}Fe was used to investigate a number of hemoglobin compounds. Techniques are being used to incorporate the isotope ^{57}Fe into hemoglobin so that significant increase in line intensities and higher resolution of the Mössbauer spectra can now be obtained. Uncorrected resonance absorptions of more than 20% have been measured. Mössbauer spectroscopy is useful for the investigation of various iron spin states in hemoglobin and may be used to identify multiple spin states in some molecules. Some recent experiments involving the coexistence of high and low spin iron and a brief review of the applicability of Mössbauer spectroscopy for the investigation of iron containing biological molecules are presented. (auth)

2481 RESULTS OF EXPERIMENTAL INVESTIGATIONS ON THE DOSE FRACTIONATION PROBLEM. Kaercher, K. H.; Kaneda, H. (Univ., Heidelberg). Fortschr. Geb. Roentgenstr. Nuklearmed., 107: 406-14(Sept. 1967). (In German).

In comparison with fractionated x-irradiation and a small single dose, autoradiographic and histophotometric investigations on rats showed that a high single dose was of decisive influence on the DNA synthesis of the tumor and in this way on its recession. Results were in agreement with investigations on specimens of human tumors. For tumors that were more differentiated and highly resistant against radiation the method of using the higher single dose with prolonged intervals was to be preferred when compared with the conventional method. (auth)

2482 INTRA-ARTERIAL THERAPY: SITE OF INJECTION AND LOCAL CONCENTRATION. Widmer, Leo K. (Univ., Basel). Angiology, 17: 738-42(Oct. 1966).

A radioisotope method was developed for assessing the effectiveness of intra-arterial chemotherapy. The local concentration of a drug is best assessed by injecting a drug labeled with a γ-emitting isotope, e.g. ^{131}I, and externally monitoring the activity-time course at the site in question. Since labeling is expensive, instead of a labeled drug a solution of ^{24}Na (as NaCl), emitting γ rays of 1.37 and 2.53 MeV was used for these experiments. Its half life of 14.8 hr is similar to that of oxytetracycline, an antibiotic currently used for intra-arterial therapy of infections in peripheral arterial disease. Observations were made in six subjects with segmental occlusions of arteries distal to the groin on the infused side. The femoral artery was injected with 10 μCi of ^{24}Na in 45 ml of isotonic saline. It was infused at a rate of 2 ml per min by an infusion pump. The γ activity was followed with scintillation detectors and rate meters during and 60 min after infusion. The activity of the two feet during intrafemoral infusion of ^{24}Na was thus compared. In most instances, in the foot where the infusion took place (ipsilateral foot), a steeper increase was noted than in the contralateral foot. In a few instances in the same patient, however, almost the same activity was recorded in both feet. Radiography with contrast media revealed that this occurred when the tip of the needle was in the deep rather than the superficial femoral artery. (BBB)

2483 PHOSPHATE METABOLISM OF X-IRRADIATED TOMATO PLANTS. Brucker, Wolfgang (Ernst-Moritz-Arndt-Univ., Griefswald, Ger.). Flora, Aby. A, 156: 197-206(1965). (In German).

The phosphate content of stem sections and crown gall tumors of sterile root cultures of tomato plants was measured over an interval of 14 days following x irradiation of 20 KR. The total phosphate content was decreased slightly, and the orthophosphate was increased. There was no definite trend in the acid-soluble P fractions. Protein phosphate was affected slightly, but lipid phosphate was decreased markedly. The deoxyribonucleate fraction was decreased about 20%, but its absolute value was very low. Large differences were observed between the deoxyribonucleate and ribonucleate fractions. Toward the end of the experimental period the decrease in P content of the acid-insoluble fractions was the greatest, amounting to 25 to 30%. In similar irradiation studies, where ^{32}P was used, the highest sp. act., after orthophosphate, was in the acid-soluble, $BaSO_4$-insoluble fraction. The total nucleic acid phosphate fraction was next highest. The sp. act. of the deoxyribonucleate fraction was low, though in the tumors it was three times as large as that in the stems. Within three days of irradiation the ribonucleate fraction decreased by ~30%. The author suggests that these changes were related to alterations of genetic control mechanisms caused by the irradiations. (BBB)

2484 EFFECTS OF PANIRRADIATION ON ENZYME ACTIVITY IN SERUM, LIVER, AND SPLEEN OF RATS. Zanolla, W. R.; Stabilini, R.; Tittobello, A.; Casolo, F.; Vergani, C. (Univ., Milan. Univ., Pavia, Italy). Radiobiol. Radioter. Fis. Med., 22: 77-85(Mar.-Apr. 1967). (In Italian).

Data pertaining to the electrophoretic characteristics and the content of alkaline phosphatase in the liver, serum, and spleen of rats subjected to whole-body x irradiation at a dose of 800 R are presented. Electrophoretic patterns and the levels of alkaline phosphatase in control rats differed from those of irradiated rats during a time lapse of 5 to 10 minutes; these differences are discussed. (auth)

2485 ACTION OF DESOXYRIBONUCLEASE AND OF RIBONUCLEASE ON THE RADIOACTIVITY OF HeLa CELLULES CULTIVATED IN VITRO IN THE PRESENCE EITHER OF THYMIDINE-^3H OR THYMIDINE-2-^{14}C. Girgis, Abdel Messih (Institut Pasteur, Paris). Compt. Rend., Ser. D, 264: 2401-4(May 17, 1967). (In French).

The largest part of the nuclear and cytoplasmic radioactivity of HeLa cells cultivated in the presence either of thymidine-^3H or thymidine-2-^{14}C was sensitive to DNAase and insensitive to RNAase; a second part was insensitive to DNAase and sensitive to RNAase (most of this was placed at the level of the nucleus); finally a third part was insensitive both to DNAase and to RNAase. (tr-auth)

2486 COMPARATIVE DEPOSITION OF ^{45}Ca, ^{65}Zn, AND ^{91}Y IN BONE. Jowsey, Jenifer; Orvis, Alan L. (Mayo Clinic, Rochester, Minn. Mayo Foundation, Rochester, Minn.). Radiat. Res., 31: 693-8(Aug. 1967).

Autoradiographic studies of bone were made after intravenous injections of three radioisotopes ^{45}Ca, ^{91}Y, and ^{65}Zn into rats, dogs, and a monkey. Counting techniques were used to measure the amount of each of these radioisotopes retained in the concentrated areas of new bone formation compared with that retained diffusely in the fully calcified bone. It was found that the ratio of concentrated to diffuse concentrations differed considerably for the three radioisotopes studied. For ^{45}Ca the mean ratio was 8.9; for ^{65}Zn the ratio was 40.1; and for ^{91}Y the ratio was 4.4. Some attempts were made to discover the mechanism of uptake of these radioisotopes in bone tissue. Both calcium and yttrium were taken up in association with the mineral phase of bone, but in a different way. The mechanism of the uptake of ^{65}Zn remains obscure. (auth)

2487 UPTAKE OF RADIOACTIVITY BY AQUATIC PLANTS AND LOCATION IN THE CELLS. II. UPTAKE OF ^{144}Ce BY THE FRESHWATER PLANT NITELLA OPACA. Hampson, M. A. (Radiobiological Lab., Lowestoft, Eng.). J. Exp. Bot., 18: 34-53 (Feb. 1967).

The uptake of ^{144}Ce by Nitella from pond water at pH 7.7 without added carrier was recorded over a period of 207 days, separate measurements being made for each of the main components of the cell. Some of the Nitella cells were then transferred to water, which contained no radiocerium, for measurements over an additional 54 days. Cerium-144 equilibrium was approached after 100 days, with the whole plant having 26,000 times the activity of the water. Under these conditions most of the ^{144}Ce was located in the cell wall, though small but significant amounts entered the protoplasm and cell sap. It was apparent that ^{144}Ce, freshly taken

up either into the cell wall or into the interior, was freely exchangeable, but after a short period (~10 days) the ^{144}Ce became more firmly bound to the plant, and was not released again. Outstanding differences noticed between the location of ^{144}Ce in Nitella opaca and of Y in Ulva lactuca are discussed. (BBB)

2488 UPTAKE OF RADIOACTIVITY BY AQUATIC PLANTS AND LOCATION IN THE CELLS. I. THE EFFECT OF pH ON THE ^{90}Sr AND ^{90}Y UPTAKE BY THE GREEN ALGA ULVA LACTUCA AND THE EFFECT OF STABLE YTTRIUM ON ^{90}Y UPTAKE. Hampson, M. A. (Radiobiological Lab., Lowestoft, Eng.). J. Exp. Bot., 18: 17-33(Feb. 1967).

Uptake of ^{90}Sr and ^{90}Y by Ulva lactuca from sea water was measured over 179 days. In sea water at normal pH (8.0) and without added carrier Ulva reached a ^{90}Sr equilibrium at 0.32 times the concentration in the water within three hr, but rapidly depleted the water of ^{90}Y. Addition of 0.15 ppM of stable Y led to the establishment of an ^{90}Y equilibrium within three hr, with the Ulva having a concentration factor of 550. Without added carrier ^{90}Y remained on the outer surface of the plants, but when carrier was added ^{90}Y entered the cells and was deposited in the protoplasmic inclusions. Strontium-90 was located only in the protoplasmic inclusions. Uptake was investigated in a pH range 5.1 to 8.0. Progressive reductions of pH from 8.0 to 6.5 led to a small increase in the amount of ^{90}Sr uptake but to a large increase in the ^{90}Y uptake. However, in the pH range 5.8 to 5.1 ^{90}Y uptake was greatly reduced. External pH below 6.0 caused death of the alga within 5 days. The effect of pH on Sr uptake is thought to be due to changes in equilibrium in the carbonate-bicarbonate system. The effects of pH and stable Y concentration on ^{90}Y uptake are discussed in terms of changes in the state of Y in the sea water, resulting in increased availability to the plant, and of changes in the nature of the plant surface resulting from its physiological response to lowered pH. (BBB)

2489 APPLICATIONS OF DEUTERIUM IN BIOLOGICAL RESEARCH. Katz, Joseph J. (Argonne National Lab., Ill.); Crespi, Henry L.; Blake, Martin I. pp 455-68 of Isotopes in Experimental Pharmacology. Roth, L. J. (ed.). Chicago, Univ. of Chicago Press, 1965.

The chemical and biological consequences of extensive isotopic replacement of hydrogen by deuterium are reviewed. The studies described include those of deuterium isotope effects with fully deuteriated proteins and carbohydrates, now available from fully deuteriated microorganisms grown in 99.7% D_2O. The secondary isotope effect on protein conformation and the role that hydrophobic or nonpolar protein bonding plays in the genesis of the isotope effect is discussed. Applications of deuterium in the chemotherapy of experimental tumors are included. (TSS)

2490 STUDIES ON BETA RADIOACTIVITY OF MINERAL COMPONENTS OF MEDICINAL HERBS. Pelczar, Tadeusz (Medical Academy, Krakow). Acta Pol. Pharm., 23: 132-6 (1966).

The β activity, resulting from both natural radioisotopes and from fallout, was determined in the root, bark, leaves, fruit, or flowers of a large number of plants used for medicinal purposes. Total β radioactivity was measured in the ash with a G-M counter and potassium content in ash was determined by flame photometry. The isotope ^{40}K was the principal radioactive component of the seeds, fruits, and roots. The difference indicated by the total activity minus the activity of ^{40}K showed that increased accumulation of this natural radioisotope was mainly in the herbs classed as tannic, flavenoid, and mucinous drugs. Different species of the same herb families showed widely varying activities, showing the selective accumulation of some radioisotopes in certain species. (BBB)

2491 ELEMENTAL COMPOSITION OF SOME PELAGIC FISHES. Goldberg, Edward D. (Scripps Inst. of Oceanography, La Jolla, Calif.). Limnol. Oceanogr., 7: Suppl., 72-5(1962).

To evaluate the potential uptake of fission products and the potential sites of concentration of various elements, studies were made in connection with Operation Wigwam to learn something of the concentration of naturally occurring elements in the organs of pelagic fishes. This was undertaken by studying the elemental composition of various organs of tunas and other pelagic fishes. The data indicated that the elements existing most probably as cationic species in sea water (Mn, Cu, Ni, Zn, etc.) tend to be concentrated in the internal organs. The alkaline earths (Ca and Sr) concentrate in the hard tissues, and Sr appeared more strongly taken up in the flesh than Ca. (BBB)

2492 DISTRIBUTION OF ^{65}Zn IN PEAR TREES FOLLOWING BARK INJECTION. Millikan, C. R.; Hanger, B. C. (Victorian Plant Research Inst., Burnley Gardens, Australia). Aust. J. Agr. Res., 18: 85-93(Jan. 1967).

Two-yr-old pear trees (Packham Triumph), growing in 15-gal drums, were bark-injected with ^{65}Zn two months after bud burst. To some injection doses, nonradioactive Zn with or without EDTA was also added. The ^{65}Zn only moved from the injection point when extra Zn was included in the dose; EDTA further enhanced this movement. The ^{65}Zn was distributed to spurs and laterals on the injected leader, situated above and on the same side as the point of injection. Limited downward movement was also evident. The ^{65}Zn was detected in new growth formed after injection, and also in blossom, leaves, and new lateral growth produced on the injected leaders in the following season. It was found that ^{65}Zn accumulated at the nodes on laterals, and in the petioles, midrib, and major veins of the leaves. Although nodal accumulation was similar for pear and subterranean clover, the pattern of distribution of ^{65}Zn in the leaves of these two species was very different. Radioautographs of the pear leaves revealed a much greater concentration of ^{65}Zn in the vascular system than in the interveinal tissue, and an identical pattern of distribution of ^{65}Zn was noted in the leaves of the loganberry. By contrast, radioautographs showed a uniform distribution of ^{65}Zn throughout the leaflets of subterranean clover. (BBB)

Ecology

2493 (UCRL-Trans-1356) FUNCTIONAL ARRANGEMENT AND ORGANIZATIONAL PROBLEMS OF A LABORATORY FOR MONITORING RADIOACTIVITY IN THE BIOSPHERE. Danali, Susan D. Translated for Univ. of California Lawrence Radiation Lab., Berkeley, from "Democritus" Nuclear Research Center, Athens (Greece) Report 3-4, 1966. 97p. Dep. CFSTI. JCL $9.10 fs, $3.26 mf.

A detailed proposal is made for the organization and operation of a Laboratory for the Detection and Identification of the Radioactive Contamination of the Biosphere. (H.G.D.)

Genetics and Cytogenetics

Refer also to abstract 2545.

2494 UNSTABLE AUREA MUTANTS IN THE TOMATO. Persson, A. R. (Agricultural Coll. of Norway, Vollebekk). Qualitas Plant. Mater. Veg., 13: 299-304(Aug. 15, 1966).

Induction by x-ray of xanthalba and aurea, 2 types of chlorophyll mutants, is reported. Xanthalba plants have a chlorophyll amount intermediate between albina and xantha, or less than 1% that of normal plants. The mutations are lethal. Aurea has a chlorophyll deficiency due to a heterozygotic condition (incomplete dominance). The heterozygote is gold colored and by selfing usually gives a segregation into 1 green(+/+):2 aurea (A/+):1 xanthalba (A/A). The chlorophyll content of the aurea type is about $\frac{1}{3}$ of the normal plant. The xanthophyllic A (Xa_1) gene was induced by x-ray treatment of seeds of the cultivar Selandia. It was first observed in the progeny from a variegated X_1 plant. A new variegated type was produced by x-ray treatment, in a dose range from 5000 to 25,000 R. All the X_1 plants from 15,000 R treatment and higher showed some kind of reaction to the treatment, i.e., arrested growth and leaf distortion. Two A/+ plants from seeds subjected to the 15,000 R treatment had a spotted appearance, one with green and white spots, and one with green spots. The latter had a pollen fertility of about 1%, and only by crossing it with a normal plant were seeds obtained. This plant had two kinds of branches, one with green spots which gave a few seeds, and another with highly distorted leaves and flowers and from which no seeds were obtained. Preliminary analysis of the variegated material suggested a chromosomal basis for the x-ray-induced variegation. Variegation seemed to be associated with breakage of the chromosome 10. (BBB)

2495 GENETIC CROSSING OVER IN BOTH SEXES OF MEGASELIA SCALARIS. Mainx, F.; Doschek, E. (Univ., Vienna). Mol. Gen. Genet., 99: 203-18(1967). (In German).

Recombination in Megaselia males as compared to females is variably reduced. The magnitude of the reduction of crossing-over values within the different chromosomes and within the different zones of chromosomes depends on the site of the sex-realizer. Crossing-over in females is of the common meiotic type. Crossing-over in males is probably premeiotic, spermatogonial. Double crossing-over between the sex-realizer and the next marker and between this and the second marker shows always a high negative interference. Low temperature and x-irradiation enhance the crossing-over values in females and in males. Low temperature enlarges the interference, x irradiation reduces the interference of double crossing-over in the female. (auth)

2496 ON THE RELATIONSHIP BETWEEN GENETIC AND SOMATIC SENSITIVITY TO RADIATION DAMAGE IN INBRED MOUSE STRAINS. Storer, John B. (Jackson Lab., Bar Harbor,

Me.). Contract AT(30-1)-3314. Radiat. Res., 31: 699-705 (Aug. 1967). (NYO-3314-7).

The incidence of dominant lethal mutations in spermatozoa estimated by postimplantation death in embryos sired by male mice irradiated with 600 R and mated one day later to female mice of the same strain or to C57BL/6J female mice was measured in four strains known to differ in somatic radiation sensitivity. In the inbred embryos (from matings between mice of the same strain) there were significant differences in embryonic mortality with the ordering of sensitivity identical to the ordering of the somatic radiation sensitivity of adults of the same strain. When the embryos were hybrids (from matings to C57BL/6J females) there were no significant differences in mortality. It was concluded that there were no strain differences in the susceptibility to the induction of chromosome damage in spermatozoa, but that radiosensitive strains were more sensitive to the induced damage, and lethality in radiosensitive strains resulted from injury that was sublethal in radioresistant strains. (auth)

2497 CHROMOSOME CONSTITUTION AND GAMMA-RAY SENSITIVITY: A POSSIBLE CORRELATION IN HAMSTER CELLS CULTURED IN VITRO. Bedford, Joel S.; Hall, Eric J. (Churchill Hospital, Oxford). Radiat. Res., 31: 679-92(Aug. 1967).

Survival estimates were made for two sublines of Chinese hamster cells cultured in vitro, designated clones D and F, which had a preponderance of cells with 23 and 46 chromosomes, respectively. A digital computer was programmed to fit the best multitarget survival curves to the data by the method of least squares. The slopes of the survival curves for the two cell lines were similar, but the cell line with the largest number of chromosomes exhibited a larger extrapolation number; 8.5 for clone F, compared with 2.95 for clone D. Split-dose experiments were also performed. The recovery factor (defined to be the number of colonies formed on plates receiving the split dose, divided by the number of colonies formed on plates receiving the same total dose in a single exposure) was larger for cells of clone F than for cells of clone D, 8.5, as opposed to 4.4. These results tend to confirm previous reports in the literature that radiation response varies with chromosome number, cells of higher ploidy being more resistant. (auth)

2498 A DAYLENGTH-SENSITIVE, TALL-MUTANT PEA. Knavel, Dean E. (Univ. of Kentucky, Lexington). J. Hered., 58: 78-80(1967).

A tall mutant pea plant was found in an R_2 population that was grown from seeds of the Early Perfection variety, which were exposed to 20,000 R of γ radiation. Plants that were grown during the months of January to March from seeds of the R_2 mutant grew taller than the plants from nonirradiated Early Perfection seeds. Plants of the R_4 generation, which were grown during the months of April to June, grew taller than Early Perfection plants, but not as tall as the R_3 mutants. The mutant was daylength-sensitive for number of main-axis nodes preceding the first flower, and had its first flower at a higher-numbered node than did plants of Early Perfection when plants of both populations were grown under either long or short day conditions. The R_3 mutant plants flowered at a higher-numbered node under short days than did similar plants grown under long days. Crosses between the mutant and Early Perfection parents are described. Evidence was presented that the recessive allele (of the day length-sensitive) Sn gene, and another gene, gene complex, or cytoplasmic factor in the Early Perfection plants mutated. (BBB)

2499 ELEMENTS OF THE S-GENE COMPLEX. II. MUTATION AND COMPLEMENTATION AT THE S_1 LOCUS IN NICOTIANA ALATA. Pandey, Kamla Kant (DSIR, Palmerston North, N. Z.). Heredity, 22: 255-84(May 1967).

It was shown that true S-gene mutations, similar to those found in Oenothera, Prunus, and Trifolium, also occur in Nicotiana alata. However, in N. alata pollen-part mutations generally appeared to be lethal, unless associated with an S-bearing duplication. To induce mutations, 1000-R doses of 230-KV x rays were delivered at room temperature to whole inflorescences containing young buds, the oldest of which were in the meiotic or premeiotic stage. Earlier experiments showed that x rays applied to mature pollen grains are not effective in producing S allele mutant pollen. Mature pollen from x-irradiated buds was applied to the stigmas of nonirradiated flowers. All mutant plants produced by self pollination with or without x irradiation (X_1 plants) were test-crossed to determine which of the four kinds of mutations (pollen-part, stylar-part, both pollen- and stylar-part, and revertible) was involved in the production of the mutant seed. The results suggested that the function of the duplication is two-fold: production of dialleic heterogenic pollen grains, resulting in competitive interaction and self-compatibility; and complementation of the mutant allele, which would otherwise have been lethal in the pollen grain. Further conclusive evidence of true S-gene mutation and complementation was provided by two stylar-part mutations which do not need the fragment for their viability. In these, as in the two pollen-part mutants, competitive interaction as a basis of explanation is ruled out. (BBB)

2500 MUTATION RESEARCH WITH COCKSFOOT LEMBA R.v.P. RESULTS FROM A TREATMENT WITH X AND ^{60}Co GAMMA RAYS. De Loose, R. (Rijksstation voor Sierplantenveredeling, Melle, Belg.). Meded. Landbouwhogesch. Opzoekingssta. Staat Gent, 30: 59-68(1965). (In Flemish).

The mutagenic action of x and γ rays, combined with several pre- and posttreatments, was followed on seed of the R.v.P. cocksfoot variety Lemba (tetraploid). The seed was stored before irradiation in an atmosphere of 65% relative humidity. Extensive control tests were provided. Forced self-pollination was applied in M_1 and M_2 (bagging of a group of five inflorescences per mother plant as classified per family and per treatment). The mutation frequency differed according to the mode of expression; the number of M_1 progenies segregating for chlorophyll mutants (followed up to the M_3 generation), the number of M_2 or M_3 seedlings with chlorophyll deficiencies, or the number of M_3 seedlings with chlorophyll deficiencies obtained by cross-pollination of the M_2, that was obtained itself by selfing the M_1. The last system seemed to be the most appropriate and revealed in the optimal circumstances a doubling of the natural mutation frequency. Among a total of 175,000 M_3 inbred seedlings, corresponding to 1000 M_1 progenies, none was obtained that was completely free from the small siliceous teeth on the leaves. (BBB)

Health Physics and Safety

Refer also to abstracts 2225, 2261, 2278, 2320, and 3154.

2501 (AD-635204) FLARE HAZARDS AT SOLAR MINIMUM: DOSIMETRIC EVALUATION OF THE CLASS 2 FLARE OF FEBRUARY 5, 1965. Schaefer, Hermann J. (Naval Aerospace Medical Inst., Pensacola, Fla.). June 2, 1966. 17p. (NAMI-970). CFSTI.

The proton energy spectra for the Class two solar flare of February 5, 1965, as reported by a polar orbit satellite at five different times during the two-day period of enhanced intensity, are evaluated in terms of tissue depth doses for a semi-infinite slab with 0.1 g/sq cm shielding and for the Gemini and Apollo shield distribution. Maximum dose rates for the tissue surface are 714 millirads/hour, 81 and 11 millirads/hour, respectively. For the unidirectional beams, half value layers range from 2.6 to 5.6 millimeters of tissue. The integral flare dose over forty-four hours is 8.3 rads for the tissue surface behind 0.1 g/sq cm shielding. (auth) (TAB)

2502 (AECL-2665) ACTIVITIES OF THE BIOLOGY AND HEALTH PHYSICS DIVISION, CHALK RIVER NUCLEAR LABORATORIES. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). Feb. 1967. 59p. Dep. CFSTI. AECL $1.50.

Activities of the Biology and Health Physics Division of Chalk River Nuclear Laboratories during 1966 are summarized. Topics discussed include training programs in health physics and radiobiology; the effects of x radiation on the structure of DNA; the mechanisms responsible for the x-radioinduced death of yeast cells; the effects of x radiation on the synthesis of histones in nuclei of cells in rat liver, spleen, and thymus; the synthesis of viral proteins in a cell-free system; neutron dosimetry using a thin plastic foil etched in alkali after bombardment to produce holes at the damage sites; the detection of organically-bound iodine on charcoal-loaded filter paper; development of a scintillation technique using urine for the rapid estimation of tritium body burdens; applications of semiconductor detectors and thermoluminescent detectors for personnel dosimeters; the development of a microscopic flying-spot scanner for use in identification of stained DNA in cytological studies; the effects of radioactive wastes on the ecology of the area; the movement of ^{59}Fe through aquatic food chains; the use of ^{41}Ar as a tracer for measuring the dispersion of gases from a stock plume; the development of methods for the measurement of evaporation from lakes; a comparison of the efficiency of various filters for the removal of radioactive aerosols from ventilation exhaust air; the efficiency of respirators for removal of tritium oxides; and the establishment of maximum permissible concentrations for exposure of man to tritium oxide. A list is included of 122 publications during 1965 and 1966. (C.H.)

2503 (AECL-2756) REVIEW OF CHALK RIVER EXPERIENCE WITH TRITIATED HEAVY WATER. Bush, W. R. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). July 1967. 17p. (CONF-670218-1). Dep. CFSTI. CAN $0.50.

From Symposium on Instrumentation, Experience and Problems in Health Physics Tritium Control, Albuquerque, N. Mex.

The growth of the tritium (HTO) hazard in the NRU reactor building is reviewed and the methods and exposure guides introduced to keep the hazard under control are outlined. Tritium oxide intakes are classified as removal, caution, minor, or negligible, depending on the HTO concentration in urine. Removal exposures (20 μCi/l) are investigated and a report of the exposure incident is distributed to all Branches. The average HTO dose received in 50 removal exposures in 1966 was 230 mrem. The average received by all operating personnel was 750 mrem, received mostly from minor exposures. The largest HTO exposure resulted in a dose commitment of 4700 mrem, and 19 other single exposures exceeded 500 mrem. Most of these resulted from intake of HTO vapor through the unwetted skin of men wearing air-supplied masks and cotton coveralls. (auth)

2504 (NP–16514) K VOPROSU O SODERZHANII TSEZIYA-137 V KOSTNOI TKANI CHELOVEKA. (Determination of ^{137}Cs in Human Bone Tissue). Golutvina, M. M.; Yartsev, E. I.; Kazakova, T. A. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow). 1965. 10p. (In Russian). Dep.

The content of ^{137}Cs in bone tissue of Moscow residents dying in 1961, 1963, and 1964 was determined. For the analysis, material taken from 99 types was used. The femur was the principal type investigated. It was shown that the content of ^{137}Cs in bone tissue in adults in 1963-1964 was 0.12 pc/g ash; in children it was 2 to 4 times greater. The ratio of the content of ^{90}Sr to the content of ^{137}Cs in the bones of adults varied from 3 to 4. (tr-auth)

2505 (NP–17042) DATA FROM RADIATION PROTECTION PROGRAMS. Volume 5, Number 7. (Department of National Health and Welfare, Ottawa (Ontario). Radiation Protection Div.). July 1967. 21p. Dep.

Data are presented on the total β activity in airborne fallout particulates collected daily at 24 stations throughout Canada; the total β activity in samples of atmospheric precipitation; and the content of ^{137}Cs and ^{90}Sr in milk samples collected during May, 1967. Data are also included on radioactivity in the environs of Canadian reactors during June, 1967. (C.H.)

2506 (NYO–3086-7) RADIOACTIVITY STUDIES. Annual Progress Report, October 1, 1966–October 1, 1967. Eisenbud, Merril; Kneip, Theodore J. (New York Univ., N. Y. Inst. of Environmental Medicine). Contract AT(30-1)-3086. 88p. Dep. CFSTI.

To better define the dose to the lungs and other organs of indigenous rodents on the Morro do Ferro, further studies were made of the fate of inhaled thoron and daughter products in laboratory rats. Specific activities were measured in the organs of unrestrained rats following 48 hours exposure to thoron, ^{212}Pb and ^{212}Bi. The distribution found among the organs is, in order of specific activity, G. I. tract, lungs, skin, kidneys, trachea and bronchi, red cells and liver. The unrestrained rats were estimated to accumulate 40% more ^{212}Pb than restrained rats, the difference being due to ingestion of ^{212}Pb from various surfaces. Thoron daughter product measurements in rodent burrows on the Morro do Ferro showed the ^{212}Pb concentrations to be 0.1% of equilibrium. The field data together with the laboratory studies suggest that the dose to bronchial epithelium of rats living in these burrows is about 300 rads per year. The program of measurements of former radium dial painters undertaken in support of the New Jersey Health Department Radium Project was completed. Best estimate of the biological half-life of skeletally deposited radium in these cases is 14 ± 2 years. This result agrees well with currently accepted values of other investigators. Breath radon studies have confirmed the 0.34 radon retention factor for ^{222}Rn. The correlation reported in the previous annual report between minute-volume and fractional radon elimination was supported by additional data. Further studies were undertaken to define the dosimetric implications of our observation that the radium content of aortas from radium dial painters is more than an order of magnitude higher than in other soft tissues. It has been found that the deposition site is in the media tunica. Pilot studies in two rabbits of the rate of deposition in soft tissues have not provided definitive data, but a deposition pattern was assumed and the radiation dose to the medial layer calculated as 0.5 to 2.5 rad in 40 years for the two dial painter's. The effect of possible variations in deposition rate and the effect of plaque formation are discussed. An extraction, atomic-absorption method was developed for the separation and determination of metallic trace elements in acidic solutions (pH < 2). The procedure provides a simple method for separation of trace metals from the calcium phosphate matrix of bone and teeth. Overall procedural tests were performed with bone samples spiked with lead, zinc, copper and iron and quantitative recoveries were demonstrated. The new analytical method was used to study the distribution of lead and zinc in the bones of a human skeleton and to measure the lead in age-related teeth samples. Lead in teeth shows a correlation with age extending from less than 10 to 60 years. This finding is in contrast to the finding of others that the lead content of human bone does not increase beyond age 45. (auth)

2507 (ORNL-TM–2026) DOSE RATE FROM HIGH-ENERGY ELECTRONS AND PHOTONS. Alsmiller, R. G. Jr.; Moran, H. S. (Oak Ridge National Lab., Tenn.). Oct. 20, 1967. Contract W-7405-eng-26. 11p. Dep. CFSTI.

Electron-photon cascade calculations were carried out, and energy deposition as a function of depth was obtained for monoenergetic electrons (0.1 to 20 GeV) and photons (0.01 to 20 GeV) normally incident on a semi-infinite slab of water 30-cm thick. The calculated results are in approximate agreement with experimental data for the case of 5.2-GeV incident electrons. (auth)

2508 (SC-TM–67-405) ESTIMATING BODY BURDEN LEVELS OF RADIOACTIVE MATERIALS FROM URINARY EXCRETA DATA FOR A NUMBER OF IMPORTANT RADIONUCLIDES. Crites, Thomas R. (Sandia Corp., Albuquerque, N. Mex.). Aug. 1967. Contract AT(29-1)-789. 36p. Dep. CFSTI.

Graphs are presented relating urinary excretion levels to body deposition as a function of time for a number of medically and industrially important radionuclides. (auth)

2509 THYROID ^{131}I BURDENS IN MEDICAL AND PARAMEDICAL PERSONNEL. Blum, Manfred; Liuzzi, Anthony (New York Univ., N. Y.). J. Amer. Med. Ass., 200: 992-4 (June 12, 1967).

Measurements were made of thyroid ^{131}I burdens in 36 medical and paramedical personnel exposed to radioiodine in their work. Since burdens were generally expected to be very low, a sensitive detection system was used. It consisted of a low background steel room, with two 3 × 3-in. NaI(Tl) scintillation crystals placed in contact with the neck. With a 400-channel pulse-height analyzer energy bands were established corresponding to ^{40}K, ^{137}Cs, and ^{131}I. The average thyroid ^{131}I burden in 60 healthy adults without known radioiodine exposure was 12.3 pCi. Eleven physicians and physicists who supervise the activities of diagnostic isotope laboratories contained 22 to 343 pCi in their thyroid glands, with an average of 92 pCi. Thyroid burdens for 25 technicians performing studies routinely done in diagnostic isotope laboratories ranged from 35 to 18,131 pCi with an average of 2374 pCi. Four physicians were studied before and after they administered 100-mCi doses of sodium iodide-^{131}I to patients. Although they were cautious to avoid self-contamination with the isotope, their thyroid burdens increased by as little as 19, 29, and 54 pCi in 3 and as much as 1805 pCi in the fourth 24 hr after ^{131}I was handled. Thyroid ^{131}I burdens measured in nurses and aides attending one of the treated patients, who required minimal attention, reached an average of 262 pCi 24 hr after contact began. The maximum permissible value for annual occupational exposure to radioiodine recommended by the Federal Radiation Council is 30,000 mrad. The inferred doses observed were below this level. (BBB)

2510 RADIATION EXPOSURE TO GONADS STUDIED. J. Amer. Med. Ass., 199: 31 (Feb. 13, 1967).

Data relating to diagnostic radiation doses to the gonads received in the United States are briefly reviewed. Diagnostic examinations accounted for about ⅓ of the radiation absorbed by the reproductive organs of Americans during 1964. The figure of 55 mrad of absorbed radiation is lower than most previous estimates. This amount of man-made radiation is added to the 120 mrad of natural background radiation received annually in most parts of the country. There is no indication of major excesses in radiation exposure for diagnostic purposes. However, by reducing the size of the beam used and by carefully limiting areas of the body exposed during routine x ray examinations, it should be possible to reduce the annual genetic dose in spite of the increased use of x rays in medicine. Half of all diagnostic x ray studies consists of chest examinations, but these contributed only four mrad to the total genetic exposure. Examinations of the colon accounted for 10 mrad, those of the lumbar or lower spine 10, intravenous pyelograms seven, pelvis four, and upper gastrointestingal system three. All other examinations including the head, neck, arms, and legs accounted for 17 mrad of the annual total of 55. Exposures to men accounted for 44 mrad, exposures to women 10, and those to children one. This correlated with estimates that men receive more x ray studies than do women, during their early adult years. Film procedures accounted for an estimated 53 of the 55 mrad, in spite of the higher exposure involved in fluoroscopy, because relatively few persons require the more complex studies and because many of those who do are beyond their reproductive years. Sixty-seven million Americans received a total of 115 million medical diag-

nostic x ray examinations during 1964, about twice as many as residents of most European countries. (BBB)

2511 RADIOACTIVE INGROWTH OF ^{210}Po IN TOBACCO PLANTS. **Francis, C. W.; Chesters, G. (Univ. of Wisconsin, Madison). J. Agr. Food Chem., 15: 704-6(July-Aug. 1967).**

Polonium-210 is an α-emitting radioelement found in tobacco and thought to be a possible initiator of bronchial cancer in cigarette smokers. An investigation was initiated to evaluate the extent of $^{210}Po_{84}$ ingrowth in tobacco and to determine the possible existence of an equilibrium between $^{210}Pb_{82}$ and $^{210}Po_{84}$. The $^{210}Po_{84}$ content of cured tobacco leaves was determined at intervals of three months for one yr. Increasing concentrations of $^{210}Po_{84}$ were found after storage, thereby proving the existence of $^{210}Po_{84}$ ingrowth from some radioactive precursor. To determine the precursor responsible, it was necessary to consider the decay chain of $^{238}U_{92}$ and establish criteria for the existence of an equilibrium between $^{210}Po_{84}$ and $^{210}Pb_{82}$. The $^{210}Po_{84}$ in leaves of tobacco was shown to be derived from and in radioactive equilibrium with $^{210}Pb_{82}$. Linear extrapolations of $^{210}Po_{84}$ ingrowth obtained by a modified Bateman equation indicated that $^{210}Pb_{82}$ entered the tobacco leaves during the growing season either by plant uptake or by deposition in natural radioactive fallout. (BBB)

2512 PUBLICATIONS ON RADIATION PROTECTION. **Becker, K. Atompraxis, 12: 525-8(Oct. 1966). (In German).**

Periodical publications appearing in various countries, with data on the coverage provided by them in the field of radiation protection, are presented. Reference is also made to the annual and special reports of the radiation protection sections of major research institutes, which frequently contain indications concerning unpublished studies. (Occup. Safety and Health Abstr.) (TSS)

2513 EXPOSURE TO THE MATERNAL OVARIES RESULTING FROM PREGNANCY RADIOGRAPHS AS A FUNCTION OF OVARIAN LOCATION. **Nikl, I. (National Research Inst. for Radiobiology and Radiohygiene, Budapest). Brit. J. Radiol., 40: 453-8(June 1967).**

Seven different ovary positions were selected on both right and left sides within an inhomogeneous phantom simulating the conditions of full-term pregnancy. Exposures were measured at these sites by a condenser ionization chamber, for antero-posterior, postero-anterior and lateral radiography at three different x-ray qualities, namely, 81 kV with inherent filter, with 2 mm Al added and 110 kV with 4 mm Al total filtration. With the antero-posterior projection the ovarian exposure using the latter two qualities was reduced to 75 to 50 and 41 to 14 percent respectively, as compared with the first. The exposure from postero-anterior radiography was lower by a whole order than that from antero-posterior views, irrespective of the quality. In the case of lateral views, exposure to the ovaries proximal to the tube was higher by two orders than that for the corresponding distal site. The use of the harder beams caused a notable reduction in exposure to the proximal sites as compared with unfiltered radiation. For the distal sites the second quality caused rather less improvement, while for the third quality, there could be either a small increase or decrease in exposure. (auth)

2514 REPORT OF THE COMMITTEE ON PUBLIC HEALTH AND RADIOLOGICAL FALLOUT. **Schroeder, R. J.; Brandly, P. J.; Courter, R. D.; (and others). Proc. U. S. Livestock Sanit. Ass., 68: 241-7(1964).**

The report of a Federal Committee sponsored by the Dept. of Health, Education, and Welfare relating to fallout and other health hazards pertinent to livestock is outlined. It concerns mainly the Protection Action Guide. The Guide is defined as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. The projected dose is the dose that would be received in the future by individuals in the population group from the contaminating event if no protective action is taken. The Protective Action Guide for ^{131}I is 30 rad to the thyroid. If the projected dose exceeds the Protective Action Guide, protective action is indicated. Of various actions that might be effective in averting the major part of the potential exposure, two appear to provide the most acceptable combinations of maximum effectiveness and minimum undesirable consequences. One of these is the diversion of fresh milk to provide unaffected milk in the contaminated area, and to use the affected milk in the production of dairy products that may be conveniently stored until the ^{131}I has effectively decayed; a matter of a few weeks. The other is the substitution of stored feed for pasturage, until most of the ^{131}I has decayed. The report indicates the following changes in the fallout situation since 1963. Short-lived radioisotopes produced by nuclear testing, ^{131}I and ^{89}Sr, have disappeared from the environment. The inventory of the long-lived isotopes ^{90}Sr and ^{137}Cs in the atmosphere by mid-1964 was reduced to one-half that in January 1963, at the end of the last test series. Long-lived isotopes reached a delayed peak in the diet during 1964 and will decrease in future years. (BBB)

2515 RADON LEAKAGE FROM SEALED RADIUM SOURCES IN MEDICAL USE. **Bayliss, Roger J. (Dept. of Public Health, Sydney). Med. J. Aust., 1: 496-8(Mar. 11, 1967).**

Hazards of Rn leakage from Ra tubes, needles, and plaques, used for radiotherapy, are considered, and a technique and instrument were developed to test Ra sources for Rn leakage. The possibility of a build-up of Rn gas in storage rooms with subsequent exposure of personnel to the gas is also considered. To test these sources, they were placed in a sealed container, at the ends of which were two electrodes carrying a potential of 300 v d-c. If radon gas was escaping from the Ra capsule, it was found that β-γ activity was deposited on both electrodes, 90% of the total being found, on the cathode and 10% on the anode. After half an hour the cathode planchettes were removed and counted with a thin end-window Geiger tube. The activity collected was calculated. The greatest hazard from leaking sources of Ra occurs when occupants of rooms where the sources are stored are exposed to the Rn gas emitted near the source. This factor was used as the criterion when determining whether a plaque was leaking excessively. A hypothetical arrangement is considered whereby the plaque is stored in a room measuring $10 \times 10 \times 10$ ft. If five air changes per hr are assumed, an air change of 2.36×10^6 ml/min, and the maximum permitted concentration of Rn in air for the general population is 3×10^{-10} μCi/ml of air, the permitted leakage from the plaque will be 7.1×10^{-4} μCi/min. Therefore, the permitted standard of leakage was taken at 10^{-3} μCi/min. Causes of leakage of Ra containers are; mechanical rupture, due to poor handling techniques and incorrect sterilization, imperfect sealing, which may be ruptured by gas pressure within the source, and action of radiation on the solder seal. The first listed above is probably the main cause of leaking sources. (BBB)

2516 LASERS AND MASERS: HEALTH HAZARDS AND THEIR CONTROL. **Daniels, Roswell G.; Goldstein, Bernard (Dept. of the Army, Washington, D. C.). Fed. Proc., 24: Transl. Suppl. 14, 27-30(Jan.-Feb. 1965).**

Some variables involved in tissue damage caused by exposure to laser and maser sources are examined preliminary to an evaluation of definable aspects of the interaction between the agent (laser beam), the host (man), and the environment involved (lab and field). The most susceptible body organ is the human eye, since the cornea and lens of the eye focus laser energy upon the retina, concentrating it several fold. The host factors influencing the occurrence of body damage upon exposure are as follows: pigmentation of the tissue; the more concentrated the melanin in the tissue, generally the more absorption; vascularity or blood circulation afforded the tissue; blood flow tends to maintain tissue temperature and reduce damage from heat; and spectral absorption of the energy; retinal tissue absorption is maximal for wavelengths of about 4000 to 5500 Å and diminishes as wavelength increases. Tentative guidelines are proposed for handling lasers in laboratories. (BBB)

2517 STUDIES OF α RADIOACTIVITY IN RELATION TO MAN. **Hill, C. R.; Osborne, R. V.; Mayneord, W. V. (Royal Cancer Hospital, Surrey, Eng.). pp 395-405 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.**

A set of techniques developed for the investigation of natural α radioactivity in man is described; large area α spectroscopy, without recourse to chemical separation, and high resolution α spectroscopy were used. Results of measurements are given to illustrate the applicability and efficiency of the techniques; partial descriptions of the pulse ionization chambers used are included. By adopting an experimental approach that accounted for all α-emitting nuclides potentially present in a material, a fairly comprehensive picture was constructed of the main contributions to long-lived natural α-radioactivity in man. One result of this approach was to indicate the relative importance of certain nuclides that previously attracted little attention. In particular, polonium-210 appeared to be responsible for mean dose rates of several mrem/hr in normal human bone and reproductive organs. A sensitive means for studying the metabolism of some of the potentially hazardous natural and artificial heavy radioelements in persons accidentally exposed is also provided by this experimental approach. (B.H.S.)

2518 RICHTLIJNEN VOOR STRALINGSBEVEILIGING IN ZIEKENINRICHTINGEN EN POLIKLINIEKEN. (Directives for Radiation Protection in Hospitals and Polyclinics). **The Hague, Health Council, 1966. 145p. 6.80 Nfls.**

Directives drawn up by a committee of specialists include

information on the following subjects: general items (basic concepts and their definitions, maximum permissible radiation doses, radiation monitoring, medical control, contamination); radiation protection in the use of x rays for diagnostic and therapeutic purposes; handling of stationary sealed radioactive sources; handling of portable sealed radioactive sources; handling of unsealed sources; compilation of parameters in graphs and tables including definitions. The Radioactive Substances Decree issued within the framework of the Netherlands Goods Act, the Ionising Radiations Safety Decree and other legal provisions are reproduced in the appendix. (Occup. Safety and Health Abstr.)

Medicine

Refer also to abstracts 2344, 2345, 2457, 2539, 2543, and 2550–2554.

2519 (COO-245-7) CLINICAL EVALUATION OF ^{137}Cs TELETHERAPY. Final Report. Lampe, Isadore (Michigan Univ., Ann Arbor. Alice Crocker Lloyd Radiation Therapy Center). May 1967. Contract AT(11-1)-245. 31p. Dep. CFSTI.

Details of clinical radiotherapeutic experience with ^{137}Cs-teletherapy units on 834 patients with intrathoracic neoplasmas, chiefly carcinoma of the lungs; head and neck cancers exclusive of brain tumors; or lymphoblastoma are presented. Cesium-137 as a teletherapy source is compared with ^{60}Co, and the findings are discussed. It was concluded that ^{137}Cs cannot be used to maximum advantage as a teletherapy source as can ^{60}Cs, but that ^{137}Cs is useful for clinical radiotherapy; these uses are discussed. (B.H.S.)

2520 (COO-1422-17) BONE MINERAL CONTENT AS A FUNCTION OF BONE DIAMETER IN CORTICAL BONE. Sorenson, James A.; Sadrzadeh-Raffii, Ali; Cameron, John R. (Wisconsin Univ., Madison. Dept. of Radiology). Aug. 1, 1967. Contract AT(11-1)-1422. 26p. Dep. CFSTI.

The mineral content of cortical bone in the radius and humerus was measured along with bone diameter in a series of normal subjects and in persons with diagnosed or suspected bone demineralization. The mineral content was determined by the photon absorption technique. The bone diameter, or width, was taken to be the distance scanned between the points at which the photon transmission ratio was 70% of its value through the soft tissue adjacent to the bone. The uncertainty in the measurement of bone width was estimated at 2% (standard deviation). Data obtained on bone mineral content in normal subjects and radiographically diagnosed osteoporotics are presented in tabular and graphic form. A procedure for diagnosing low bone mineral content for the radius is described. (B.H.S.)

2521 (ORNL-IIC-10(Vol.1), pp 197-232) LOW-ENERGY PHOTONS IN THE LIFE SCIENCES. Preuss, Luther E.; Leahy, David M. (Edsel B. Ford Inst. for Medical Research, Detroit, Mich.).

A review of life-science applications of low energy photons shows that by far the major usage (in terms of total photons) falls into the routine and developmental domains of medicine. A critical survey for new studies in the medical area discloses that, although low energy technology is a continued use, the methods were established and were reported upon at the time of the last x-ray meeting. There are some notable exceptions to the above premise. Electron-capture isotopes have seen accelerated application. A second exception is in the realm of organ imaging, using photons in the 20- to 150-keV area. One such system, the spark camera, is described. (auth)

2522 CHRONOBIODOSIMETRIC FINDINGS ON THE ROENTGEN THERAPY OF RECURRENCES OF MAMMARY TUMOR. Merli, E. (Univ., Genoa. S. Giacomo Hospital, Novi Ligure, Italy). Minerva Radiol., Fisioterap. Radiobiol., 12: 130-3(Apr. 1967). (In Italian).

The chronobiodosimetric method is introduced and some personal cases of mammary tumor recurrences treated with roentgen therapy are reported. The results are assessed in the light of the system of chronobiodosimetric measurement and after some remarks on the treatment technique it is concluded that the most effective radical type biodoses are those between 1.90/2.10 CDE. (auth)

2523 306 CASES OF TOXIC ADENOMA: CLINICAL ASPECTS, FINDINGS IN RADIOIODINE DIAGNOSTICS, RADIOCHROMATOGRAPHY, AND HISTOLOGY; RESULTS OF ^{131}I AND SURGICAL TREATMENT. Horst, W.; Roesler, H.; Schneider, C.; Labhart, A. (Univ. fuer Radiotherapie und Nuklearmedizin, Zurich). J. Nucl. Med., 8: 515-28(July 1967).

Toxic adenoma is a frequent occurrence. In about one-third of the cases of hyperthyroidism studied, an autonomous toxic adenoma was found to be the cause. No differences were found in frequency between patients from coastal regions and those where endemic goiter is a frequent condition. The diagnosis can only be substantiated by means of a special radioiodine study, namely linear scintigraphy in combination with controls after administration of TSH and thyroid hormone (T_3). Chromatography of urine and serum does not show qualitative differences in the ^{131}I-containing compounds in Graves' disease and toxic adenoma; on the other hand, there are quantitative differences. In the case of toxic adenoma, hyperthyroidism can be cured by permanently removing the cause of hyperthyroidism. Iodine-131 therapy requires high doses of 20 to 30,000 rads/toxic adenoma. When carried out under T_3-protection of the healthy parenchyma, there is no early or cumulative risk of myxedema. The clinical course of toxic adenoma is considerably better than that of Graves' disease, as there is less risk of myxedema; moreover, there are never complications such as endocrine exophthalmus or circumscribed myxedema. The histology of the toxic adenoma is not unique and, therefore, is not a basis for diagnosis, but in 79 patients operated and histologically proved, no malignancy was found. (auth)

2524 SPLIT-DOSE INTENSIVE RADIATION THERAPY IN THE TREATMENT OF ADVANCED LUNG CANCER: A RANDOMIZED STUDY. Levitt, Seymour H.; Bogardus, C. R. Jr.; Ladd, George (Univ. of Oklahoma, Oklahoma City). Radiology, 88: 1159-61; 69(June 1967).

A randomized study of the symptomatic and objective response of two groups of patients with inoperable squamous-cell carcinoma of the lung treated by split-dose intensive radiation therapy and routine fractionated therapy is reported. With respect to symptomatic response, survival, and x-ray response, no significant difference was found in the two treatment groups. There appeared to be a lesser radiobiologic effect and increased fibroses in the experimental group. In view of this similar symptomatic and survival effect and the definite superiority of split-dose intensive therapy from a socio-economic standpoint, this mode of therapy appeared to be a more reasonable approach to symptomatic relief of patients with advanced lung cancer than routinely fractionated therapy. A different time-dose split therapy would be worth investigating to achieve a better radiobiologic effect. (auth)

2525 MECHANISM OF THE PROTECTIVE ACTION OF GED AGAINST RADIATION DAMAGE TO DNA. Kollmann, George; Shapiro, Bernard; Martin, David (Albert Einstein Medical Center, Philadelphia). Radiat. Res., 31: 721-31(Aug. 1967).

The specific viscosity was measured in unirradiated and irradiated solutions of highly polymerized salmon sperm DNA alone and containing bis(2-guanidoethyl) disulfide (GED), oxidized glutathione (GSSG), cystamine, cadaverine, agmatine, and pentamethylene diguanidine (PMDG). Radiation-induced decrease in viscosity was almost completely prevented by 10^{-3} M GED up to 100 kR, at which dose the viscosity of the unprotected DNA solution approximated that of the solvent. When viscosity was measured at 90°C to study the effect on single strands, radiation effect and GED protection of DNA were demonstrated with doses as low as 100 to 200 R. GED had to be present during irradiation for protection but could be removed by dialysis after irradiation without loss of protection. Equilibrium dialysis demonstrated binding of GED to DNA. Other disulfides, GSSG, and cystamine showed less binding to DNA and also showed less protection. The diamine, cadaverine, and the diguanidine, PMDG, were bound to DNA equally well as cystamine and GED, respectively, but showed no protection. The mechanism of action of GED appears to be that of a localized radical scavenging at the surface of the DNA molecule. (auth)

2526 CLINICAL OBSERVATIONS OF 67 CASES OF LEUKEMIA. Ishimaru, Mitsito (Nagasaki Atomic Bomb Hospital); Alitomi, Tadao; Danno, Hachiro; Nakamura, Tadashi; Oochuru, Sinn. Nagasaki Igakkai Zasshi, 40: 623-5(Aug. 1965). (In Japanese).

Clinical observations on 67 cases of leukemia diagnosed from May, 1958 to September, 1964 are reported. Among them were 53 adult patients and 14 children. The adults included 37 atomic bomb survivors, consisting of 23 cases of the acute myeloid type, 9 of chronic myeloid type, 2 chronic lymphatic type, and 1 acute lymphatic type. In the early period, chronic bone marrow leukemia cases predominated, then number of acute myeloid leukemia cases increased proportionately in the late period. There was no specific characteristic of chronic myeloid leukemia in atomic bomb survivors. The typical chronic myeloid leukemia patient showed 65% hemoglobin, red cells 3,920,000, and white cells 34,000/mm^3. One patient had bleeding and the leukemia became

acute. His basophil counts were maintained at 50 to 60% hemoglobin 37%, red cells at 1,680,000, and white cells at 65,400/mm³. Another patient, exposed to the atomic bomb explosion at a distance of 1472 m, showed rapid progression of leukemia and death. (BBB)

2527 THE OCCURRENCE OF LEUKEMIA IN HIROSHIMA ATOMIC BOMB SURVIVORS DURING THE PAST 18 YEARS. **Watanabe, Susumu (Hiroshima Univ.). Nagasaki Igakkai Zasshi, 40: 626-8(Aug. 1965). (In Japanese).**

Clinical observations of leukemia in Hiroshima atomic bomb survivors made from 1946 to 1963 are reported. The incidence of leukemia in the Hiroshima survivors (exposed within 5000 m of the hypocenter) during the past 18 years was lowest in 1946 (1.01 per 100,000 population), then gradually increased, and reached a maximum in 1951 to 1955 (17.37 to 14.45 per 100,000). It then decreased gradually (6.31 in 1963). The mortality from leukemia showed the same trend as the incidence rate; that is, the mortality was lowest in 1946 (1.01 per 100,000 population), reached a maximum in 1951 to 1956 (14.31 to 14.49), and decreased gradually (8.42 in 1963). The mortality from leukemia in atomic bomb survivors in 1963 was 2.92 times higher than the leukemia mortality for the whole of Japan in 1961. During the past 18 years there were 303 cases of leukemia in Hiroshima and 190 were among atomic bomb survivors. The incidence rate per 100,000 population for all Hiroshima residents was 4.79 and in bombing survivors 10.84. There were 275 fatal cases and among these 174 were bombing victims. As compared with the data for the whole of Japan during 1946 to 1961, the mortality for all leukemia cases in Hiroshima was two times as high and in the bombing survivors was five times as high. Since 1959, acute leukemia increased greatly and there was little difference in distribution of leukemia types between the atomic bomb survivors and other persons in Hiroshima. Most leukemia cases among bombing survivors were people exposed within a distance of 2000 m from the hypocenter. The leukemia incidence rate of the early entrants to the city after the atom bomb explosion was higher in males than females and there was a relatively high incidence of chronic myeloid leukemia in this group. (BBB)

2528 EFFECT OF HYPERTENSION AND ARTERIOSCLEROSIS ON RESPONSE TO RADIATION THERAPY OF CARCINOMA OF THE CERVIX. **Rogers, Charles C.; Levitt, Seymour H.; Crosby, Warren C.; Brandt, Edward N. Jr. (Univ. of Oklahoma, Oklahoma City). Radiology, 89: 733-6(Oct, 1967).**

A retrospective study of 60 patients with carcinoma of the uterine cervix, International Stages I and II, is presented. The results of treatment by radiation of patients with and without hypertension and arteriosclerosis were compared. Stage II patients with hypertension and arteriosclerosis had a statistically significant poorer prognosis than patients without these diseases. These findings indicate that hypertension and arteriosclerosis adversely influence the radiobiological response of carcinoma of the cervix. (auth)

2529 EXPOSURE OF SUPERFICIAL MALIGNANT TUMORS TO THE LASER: PRELIMINARY RESULTS. **Guerin, R.-A. Presse Med., 75: 1345-6(May 27, 1967). (In French).**

The effect of Ar laser radiation on human tumors was studied, and the advantage of tumor treatment by lasers is discussed in terms of two case reports. The apparatus used had a maximum power of 250 mw, and focusing gave an impact area 1 mm in diameter. Light emissions corresponded to wavelengths of 4880, 4765, 5145, and 4965 Å (blue and green light). Energy reached only a few dozen joules per square centimeter. The first case, a woman with melanoblastoma of the vulva, was given combined local radiotherapy (a total of 50,000 R of contact x rays) and laser treatment. The zone dyed with Evans blue and irradiated with the laser showed the most curative results and least injury. Three weeks after laser irradiation the treated zone appeared orange and grossly ulcerated but not edematous. Histologic examination showed the absence of malignant cells at the site of laser impact. The second case, a woman with epithelioma of the left breast, was treated initially with x rays and chemotherapy, but bone and subcutaneous metastases were noted three years later. After five months, laser treatment, with Evans blue impregnation of the skin, was administered. The irradiated nodules disappeared almost entirely; the irradiation left no side-effects and gave no sensation of pain during exposure. Effects of laser radiation on normal and malignant cells are discussed, and the use of laser radiation and ionizing radiation (x or γ rays) synergistically to eradicate tumors is considered. (BBB)

2530 APPLICATIONS OF THE SCINTILLATION CAMERA IN UROLOGY. **Winter, Chester C. (Ohio State Univ. Hospital, Columbus). Trans. Amer. Ass. Genito-Urinary Surg., 58: 67-70(1966).**

Principles and uses of the scintillation camera to visualize the kidney are outlined, and recent developments are reviewed. The unit consists of a scintillation crystal, backed by an array of multiplier phototubes with a network of fixed, signal-mixing capacitors. These, in turn, are connected through an electronic mechanism (computing circuit and pulse-height selector) that reproduces momentary light flashes on an oscilloscope screen. The flashes are co-ordinated so as to indicate the relative intensity of the radiation signal emanating from the kidney. A dynamic or continuous record of renal blood flow, function, and excretion may be obtained. Mercury-203 labeled chlormerodrin may be used, but is not as satisfactory as the radioiodine-bearing compounds. Technetium-99m has also been used effectively to outline the renal vascular system, but o-iodohippurate labeled with ^{131}I is the most satisfactory test compound for over-all renal testing. Various collimators are available, but the one giving the best resolution for renal scintiphotography contains several hundred apertures, which provide directionality of the radiation signals. Since the output picture is not now exactly synchronized with the radiation signals from the kidney, final refinement of scintiphotography to that end remains to be accomplished. Improvements would also include color readout in proportion to intensity of radioactivity, a memory oscilloscope, a larger crystal, and a positron camera. Nevertheless, the picture approximates the conventional scinti- and photoscan and has proved useful in the diagnostic study of kidney functions. Scintophotos obtained in various pathological conditions are illustrated. (BBB)

2531 USE OF BRAIN SCANS. **Graziana, Leonard; French, Joseph H.; Freeman, Leonard M.; Rapin, Isabelle; Spiro, Alfred; Zingesser, Lawrence; Avnet, Norman L. (Albert Einstein Coll. of Medicine, Bronx, N. Y.). Amer. J. Dis. Child., 113: 509-11 (Apr. 1967).**

Excessive dependence on brain scanning with radioisotopes in children with disregard to other diagnostic methods is criticized in relation to unnecessary exposure of children to ionizing radiation. One recent report is pointed out as an example, in which attempts were made to determine and localize intracranial disease in childhood by the use of brain scans. A group of 220 children was given 100 to 500 μCi of radiomercury. The report did not give the indications for using the test, but stated that scans were done on 113 of 231 children with convulsive disorders. The scan was abnormal in only two of them. This study gave a 33% rate of false-negative results, indicating that brain scan alone cannot satisfactorily rule out the presence of a brain tumor. Some believe that the radiation hazard from the use of ^{197}Hg-labeled chlormerodrin is small; it is even smaller with ^{99m}Tc-pertechnetate. However, the radiation dose to the kidneys is estimated to be 4.37 rad/mCi patient dose, and the long-range morbidity due to isotope radiation to the pelvic organs of children, or to their future offspring, is still unknown. It is concluded that the use of a test with radioactive material is not a substitute for a careful neurological examination and selected neuroradiological procedures. Except in carefully selected cases, the information obtained by a brain scan does not warrant unnecessary exposure of a child to even small doses of γ radiation. (BBB)

Radiation Effects on Animals

Refer also to abstracts 2481, 2495, 2496, 2510, 2514, 2516, 2522, 2524, 2526, and 2527.

2532 (AD-647907) A MEASURE OF NONREPARABLE INJURY TO HEMATOPOIETIC STEM CELLS IN RATS EXPOSED REPEATEDLY TO X RAYS. **Baum, S. J. (Armed Forces Radiobiology Research Inst., Bethesda, Md.). Oct. 1966. 20p. (AFRRI-SR-66-6). CFSTI.**

Erythropoiesis essentially ceases in the polycythemic rat. It was established that stimulation by exogenous erythropoietin was a measure of the capacity of the stem cell pool in this animal to release cells for erythrocyte proliferation. Polycythemic rats that were previously exposed to 300 R of x rays, and for which the rate of erythrocyte stem cell recovery was established, were given a 3-month rest period and then exposed for a second time in one experiment and for a second and third time in another. The results clearly indicated a significant decrease in the rate of erythropoietic recovery after each repeated exposure during the rapid repair phase from day 1 to day 6 postirradiation. Since this is the time when, owing to the sustained injury, the red cell renewal system is stimulated to its fullest, a reduction in the existing cell population capable of responding to erythropoietin would be noticed and would be an indicator of residual injury. It appeared, therefore, that the present experiment further substantiated the hypothesis established in an earlier report that residual injury induced in the erythropoietic system by sublethal ionizing radiation was caused by a reduction in the total stem cell space. (auth) (TAB)

2533 (BNL-50064) CELLULAR BASIS OF ACUTE RADIATION DEATH IN THE MAMMAL. Brookhaven Lecture Series Number 63. Bond, Victor P. (Brookhaven National Lab., Upton, N. Y.). Feb. 8, 1967. 15p. Dep. CFSTI.

The effects of radiation delivered to the entire body are described, and conditions under which such exposure of human beings may be encountered were outlined. It was demonstrated that the complicated clinical picture seen as the result of such exposure has its genesis primarily in the depletion of cellular elements in the peripheral blood. It was further shown that the time course and dose relationships seen can be explained satisfactorily on the basis of the kinetics of the cell populations involved and the known cellular radiobiology that pertains to these cell populations. Additional implications of the cellular approach are described, and some practical applications are given, e.g., in devising rational therapy and in dealing with some of the radiation problems potentially affecting space travel. Throughout, emphasis was placed on the fact that the body is normally in a state of dynamic cellular equilibrium, in some small measure like an airplane in flight. Some perturbations of the systems can be adjusted to or corrected for. Severe or serious perturbation, however, results in disease or even death if equilibrium is not reestablished in time. Radiation is but one of the many harmful agents that can upset the cellular equilibrium and lead to serious illness and death. (auth)

2534 (COO-1243-8) A STUDY OF THE PHYSIOLOGICAL FUNCTION AND HISTOLOGICAL CHANGES IN THYROIDS IRRADIATED WITH RADIOACTIVE IODINE. Annual Report, June 1, 1966-June 1, 1967. Dobyns, Brown M. (Western Reserve Univ., Cleveland, Ohio. School of Medicine). June 28, 1967. Contract AT(11-1)-1243. 8p. Dep. CFSTI.

Progress is reported on studies concerned with the effects of ^{131}I on the function of thyroid gland of man; DNA synthesis in irradiated (^{131}I) and stimulated thyroid glands of rats; nuclear changes in irradiated (^{131}I) thyroid tissue of man; study of nuclear changes at the time of neoplasm formation in rat thyroid following administration of ^{131}I; chromosome anomalies in circulating leukocytes of man treated with ^{131}I; and the effects of x radiation on the thyroid gland of man. (B.H.S.)

2535 ACTUAL AND ALLEGED DANGERS OF RADIATION THERAPY OF BENIGN DISEASES. Fuchs, G. (Kaiser Franz Josef-Spitales, Vienna). Radiobiol. Radiother., 8: 181-5(1967). (In German).

For decades x irradiation of inflammations and other non-neoplastic diseases were performed on a large scale. In recent years several authors reported late pathological effects, especially malignancy whereas others did not observe such injuries For an interpretation of this discrepancy, aspects of radiation biology, irradiation techniques, and dosages are discussed. Genetic injuries resulting from radiotherapy are also considered. (H.L.W.)

2536 MORPHOLOGICAL EXAMINATIONS IN INTESTINAL COMPLICATIONS FOLLOWING BIAXIAL TELECOBALT PENDULUM IRRADIATION OF CERVIX CARCINOMA. Wolfram, E.; Banaschak, A. (Humboldt-Univ., Berlin). Radiobiol. Radiother., 8: 141-7(1967). (In German).

Morphological and histochemical studies were made on sections of the intestine surgically removed after telecobalt therapy of the cervix. A marked edema of the submucosa containing neutral and acid mucopolysaccharides was noted; lesions of arteries and veins also contained mucopolysaccharides. A correlation between radiation dose and severity of injury was observed. (H.L.W.)

2537 LUNG CANCER FOLLOWING ^{210}Po INHALATION IN RATS. Yuile, C. L.; Berke, H. L.; Hull, T. (Univ. of Rochester, N. Y.). Radiat. Res., 31: 760-74(Aug. 1967).

Inhalation by three groups of rats of NaCl aerosols with small amounts of ^{210}Po added produced initial lung burdens of 0.15, 0.05, and 0.02 μCi. After 280 days, resulting accumulated lung doses were 538, 202, and 71 rads, respectively. Life span of the highest dose group was shortened, with 87% of animals dying within one year after exposure, compared to 35% for controls and the other two experimental groups. Increased incidence and severity of acute pneumonia was the chief cause of the high mortality. Radiation changes in the lung were seen only in animals exposed to the highest level of radioactivity. No primary lung tumors developed in control rats, but 41 were found in 288 exposed rats dying spontaneously during the 96-week experiment. Squamous cell carcinoma was the commonest tumor type, accounting for 55% of the total number found. Over 70% of the squamous cell tumors occurred in rats exposed to the highest dose of ^{210}Po, and many were early lesions associated with radiation injury. Pulmonary adenomas were seen only in rats exposed to low and medium doses. The highest dose appeared to be effective in preventing mediastinal lymphomas. (auth)

2538 ^{211}At-INDUCED TRANSPLANTABLE PITUITARY TUMOR IN THE RAT WITH A BRIEF ANALYTIC REVIEW OF CELL TYPES OF PITUITARY TUMORS. Ueda, Gaiko; Mori, Toshio (Columbia Univ., New York. Wakayama Medical Coll., Japan). Amer. J. Pathol., 51: 601-20(Oct. 1967).

A pituitary tumor arose in a male rat that was given a thyroid destructive dose of ^{211}At. The functional capacities of this tumor were studied in serial passages in normal and athyroid hosts by assays for TtH and by electron microscopy. In the first four passages it grew well in athyroid hosts but very poorly in euthyroid hosts. This behavior, the bioassays for TtH, and electron micrographs led to the supposition that these tumor cells were thyrotropic. When transplanted from athyroid to normal host, the first generation tumors began to develop after a long latent period and grew slowly. However, upon subpassages in normal hosts, this behavior became reversed; the tumors grew vigorously in normal hosts and poorly in athyroid hosts. The secondary changes in the tumor hosts and the electron micrographs indicated that the tumor cells carried in normal hosts were predominantly mammosomatotropic. The observations suggest that the host selected a specific tumor type from the original mixed thyrotropic and mammosomatotropic tumor. (auth)

2539 CHIMERA OF SCATTER IRRADIATION IN THORACIC ROENTGENOLOGY. Chamberlain, Richard H. (Univ. of Pennsylvania, Philadelphia); Moersch, Herman J. Dis. Chest, 51: 669-70(June 1967).

The extent of use and some aspects of the safety of roentgenologic examination of the thorax as employed in the United States are considered. In 1964, ~108,000,000 persons underwent 173,000,000 x-ray procedures involving the use of 506,000,000 roentgenograms. Of these procedures, 53,000,000 were dental, 10,500,000 were fluoroscopic, including about 15% limited to the thorax, and 3,500,000 were therapeutic. The remaining 105,000,000 were medical diagnostic, and of these ~50% were roentgenologic studies of the thorax. In evaluating the degree of safety with which x-ray examinations of the thorax are done, the first consideration is with confinement and collimation of the x-ray beam to the area of the film. Ideally, the beam should be restricted to that area, for all radiation beyond is wasted. A survey showed, however, that the mean ratio of beam area to film area in thoracic examinations, for all types of facilities, was 2.4:1. In mobile units it was 1.5:1, even though the fixed tube-screen construction makes any excess coverage entirely unnecessary. The next consideration is the amount of exposure to radiation for each film. Expressed in terms of surface-exposure integral values (roentgens X cm^2 at skin-entrance position), it includes the factor of beam area, but also those of overexposure and underdevelopment which likewise are wasteful in the use of radiation. In hospitals, the mean value was 55 for x-ray examinations of the thorax, but in private offices of practitioners who are not radiologists the value was 300. The third consideration is the significant genetic dose. Radiation exposure of the pelvic area from x-ray examinations of the thorax is small, accounting for only about 4 mrad/yr of a total of 55 mrad. This small amount could be reduced appreciably by proper collimation of the beam. (BBB)

2540 OBSERVATIONS ON IRRADIATION OF CELLS IN VITRO WITH LASER MICROBEAM. Squassabia, A.; Jucker, C.; Zanolla, W. (Univ., Pavia, Italy). Radiobiol. Radioter. Fis. Med., 22: 65-76(Mar.-Apr. 1967). (In Italian).

The effects of microbeam laser radiation on amniotic cells stained intravitally in vitro were investigated. Two active materials emitting laser light at wavelengths of 4.963 Å and 10.560 Å were used. With the 4.963 Å laser light, destruction of the focalized cells was observed; with the 10.560 Å laser light, very little cellular alteration was noted. (auth)

2541 EFFECTS OF LASER RADIATION ON CELL CULTURES. Rounds, Donald E. (Pasadena Foundation for Medical Research, Calif.). Fed. Proc., 24: Transl. Suppl. 14, 116-21 (Jan.-Feb. 1965).

In an in vitro study it was observed that Negro skin, pigmented rabbit retinal epithelium, and a line of pigmented mouse melanoma cells were immediately destroyed upon exposure to 25 J/cm^2 or more of ruby laser radiation, at an emission time of 1 msec. Their unpigmented counterparts, skin from a Caucasian donor, retinal epithelium from an albino rabbit, and a strain of mouse lung cells, showed no morphologic change for at least 24 hr following laser irradiation. After 150 J/cm^2 irradiation from a ruby laser on chick retinal epithelium, cells containing >8 pigment granules were destroyed, while those with <8 such light-absorbing bodies survived exposure to this energy level. (BBB)

2542 PRELIMINARY RESEARCH ON A METHOD FOR MEASURING RADIOSENSITIVITY OF MAMMALIAN CELLS CULTURED IN VITRO. Balestra, E.; Brambilla, G.; Cavanna, M.

(Univ., Genoa). Boll. Soc. Ital. Biol. Sper., 42: 1667-9(1966). (In Italian).

Inhibition of cultured human cells as a function of radiation dose was investigated. Stationary monolayer cultures of KB cells, originally isolated from a human epidermoid carcinoma of the nasopharynx, were maintained in Eagle's medium supplemented with 10% calf serum. The cells were irradiated with 200-kV x rays at 88 R/min to total doses of 67 to 260 R in 2 ml of medium. The cells were transferred to fresh culture medium, and seven days later assays were made on the protein content of the control and irradiated cultures by the Folin-Ciocalteau phenol reagent. Growth inhibition was expressed in terms of percentage of protein in control minus irradiated cultures. The dose of radiation causing 50% inhibition of growth of the cultures after seven days was ~150 R. At 80 R, growth inhibition was only about 8%, but at 260 R it reached 100%. The results resemble those previously found for HeLa cells. The results of this technique are reproducible, and are recommended for assay of radioprotective agents and for testing the combined effects of antineoplastic drugs and ionizing radiation. (BBB)

2543 THE ROLE OF THE PHAGOCYTE IN HOST-PARASITE INTERACTIONS. VI. THE PHAGOCYTIC AND BACTERICIDAL CAPABILITIES OF LEUKOCYTES FROM PATIENTS UNDERGOING X-IRRADIATION. McRipley, Ronald J.; Selvaraj, Ratnam J.; Glovsky, M. Michael; Sbarra, Anthony J. (St. Margaret's Hospital, Boston. Tufts Univ., Boston). Contract AT(30-1)-3240. Radiat. Res., 31: 706-20(Aug. 1967). (NYO-3240-14).

The phagocytic and bactericidal activities of leukocytes obtained from six patients with neoplastic diseases undergoing irradiation treatment were investigated by means of serial studies. Escherichia coli, Pseudomonas aeruginosa, and Staphylococcus albus were used as test organisms. All cases showed normal activities before or during the initial stages of treatment. Four of the cases demonstrated some abnormality in leukocytic activity against the gram-negative test organisms either in the later stages of treatment or after treatment was concluded. Elevated serum gamma globulin levels were exhibited by all patients and did not significantly change during the course of irradiation. Hemagglutination titers to the gram-negative test organisms were also followed. There was no apparent correlation between serum gamma globulin levels and hemagglutinin titers, and the abnormal phagocytic and bactericidal activities of the leukocytes observed in some cases. (auth)

2544 THE DOSES RECEIVED BY THE TESTICLE IN THE COURSE OF TUMOR IRRADIATION WITH COLLIMATED BEAMS. Pedoja, G.; Rigat, L. (Istituto di Radiologia, Como, Italy). Med. Nucl. Radiol. Lat., 9: 405-14(1966). (In Italian).

The doses received by the testicle in the course of tumor irradiation with collimated beams. After a brief review of the radiobiology of the testicle, a discussion is presented of the possibility that the male gonads may sustain somatic damage in the course of tumor irradiation. Investigations consisted of determination of the doses received by the gonads per session in cases of tumors in various localizations subjected to roentgen therapy or to telecobalt therapy, but mostly the latter. The results are listed in tables. It is concluded that the doses to which the testicles are exposed in the course of treatment administered with the usual techniques are not large enough to bring about severe somatic damage such as permanent suppression of fertility; however, the latter may occasionally occur if the testicle lies in the primary beam. The gonad doses are smaller during telecobalt therapy than during traditional roentgen therapy, except in certain particular cases. The causes of these phenomena are discussed. (auth)

2545 APPLICATIONS OF GENETIC TECHNOLOGY TO MOSQUITO REARING. Craig, George B. Jr. (Univ. of Notre Dame, Ind.). Bull. World Health Organ., 31: 469-73(1964).

Experiments demonstrated useful levels of heterosis in Aedes aegypti. Characters improved by heterosis included resistance of eggs to radiation. The heterotic improvement was also evident in crosses between random-breeding strains. Crosses between the Rock and Red Eye strains of mosquitoes were made in connection with experiments on the effect of radiation on egg development. Considering the time required to complete pupation, the Rock parent required 28% and the Red Eye required 71% more time than did their F_1 progeny. It was noted that the hybrids were more resistant to radiation than the parental stocks. From eggs receiving a dose of 100 R of x rays, no Red Eye pupated but 23% of Rock did pupate. However, 65% of the F_1 pupated. This radioresistance was probably due to heterosis rather than to a specific protective mechanism. From preliminary evidence, it appeared that the rate of mitosis in the hybrids was higher and therefore repair of radiation damage was more readily effected. (BBB)

2546 RETENTION OF THE BLOOD-MEAL IN AEDES AEGYPTI FOLLOWING STERILIZATION BY CHEMICALS AND IRRADIATION. Akov, S. (Israel Inst. for Biological Research, Ness-Ziona). Ann. Trop. Med. Parasitol., 60: 482-94(1966).

Egg development in Aedes aegypti is inhibited by γ irradiation and by chemosterilants. Whether chemosterilization and irradiation cause other physiological alterations, in addition to the more conspicuous effects on fertility, was examined. The effects of metepa (tris(2-methyl-1-aziridinyl) phosphine oxide), apholate (2,2,4,4,6,6-hexa(1-aziridinyl)2,4,6-triphospha-1,3,5-triazine), and tepa (tris(1-aziridinyl) phosphine oxide) on blood-digestion in A. aegypti females is described and compared with that of γ irradiation. Elimination of the blood-meal was retarded in females previously treated with metapa, apholate, or tepa. A delay in blood-digestion was also observed in irradiated females, the retention of the blood-meal being most obvious 48 hr after feeding. The midgut proteolytic enzyme activity in females treated with chemosterilants or irradiation was not lower than in the controls. The delay in blood-digestion was not due, therefore, to a lack of midgut proteases. Retention of the blood-meal was not due to an acute toxic effect, since it occurred also when the first blood-meal was given eight days after treatment. No delay in the elimination of the blood-meal was observed following the second blood-meal. (BBB)

2547 BIOMEDICAL ASPECTS OF LASERS. Goldman, Leon; Blaney, Donald J.; Freemond, Alan; Hornby, Peter (Children's Hospital Research Foundation, Cincinnati). J. Amer. Med. Ass., 188: 302-6(Apr. 20, 1964).

Effects of ruby and neodymium glass laser radiation on animals and human cells and tissues, its hazard to human eyes, and protective measures and devices are described. The degree of damage to red cells from exposure to beams from the ruby laser can be well controlled, with damage varying from negligible to complete destruction of the cells. White cells, mostly transparent, show changes in nuclear size and granules after exposure to high-energy lasers. With laser beams attached to and focused through a microscope, it is possible to expose an area of 1 to 2.5 μ. This technique allows irradiation of selected areas of the living cell. Whether the laser beam can be mutagenic, as x rays, is considered. Studies on tissue cultures have shown significant changes in cell growth, but irradiation of Salmonella typhimurium produced no mutagenic effects with low-energy beams. Also considered is the mechanism of the laser impact on living tissues. The most obvious interaction is a thermal one. However, the changes in tissue, with its sharp demarcation of necrosis, suggest that if these changes are induced by heat, the brief period of impact, which is of the order of a millisecond, would not allow for heat transference to adjacent tissue. The possibility of shock wave in tissue as an explanation of biological effects also is considered. (BBB)

2548 THE MODIFICATION OF TRIIODOTHYRONINE-^{131}I UPTAKE OF RED BLOOD CELLS OF RATS BY X-IRRADIATION AND CAGING DENSITY. Hahn, Eric W. (Univ. of Rochester, N. Y.). Contract W-7401-eng-49. Radiat. Res., 31: 846-9 (Aug. 1967).

X irradiation and housing regimen significantly reduced the uptake of triiodothyronine by the red blood cells of the rat. Each treatment reduces the uptake by approximately 10%, and the effects are additive. (auth)

2549 THE MORTALITY EFFECT OF RADIATION ON DROSOPHILA MELANOGASTER LARVAE OF DIFFERENT AGES. Ucer, Ertar (Istanbul Univ., Turkey). Istanbul Univ. Fen. Fak. Mecm., Ser. B., 30: 171-5(1965).

To investigate the response of Drosophila of different ages, experiments were performed on 3-, 72-, and 96-hr-old larvae exposed to 1300 R of γ irradiation ^{60}Co. The 96-hr old larvae (or prepupae) passed to the pupa stage apparently without being affected by irradiation and became adults. Larvae irradiated when they were 72 hr old became pupae which did not show a statistically significant higher mortality rate than the controls. Larvae irradiated when they were 3 hr old showed a considerably higher mortality rate until they reached the pupae and the adult stage. The 3-hr-old larvae showed the highest mortality rate between 90 and 96 hr after they were irradiated. In Drosophila melanogaster larvae, in the post embryonic stage, mitosis does not occur. The variable degree of sensitivity observed in the same cells of larvae belonging to different ages may be due to changes in the physiologic condition at the different ages. (BBB)

2550 ACTINIC LESIONS OF THE COLON, SMALL INTESTINE, AND STOMACH. Barbier, F.; Versieck, J.; Elewaut, A. (Univ., Ghent). Acta Gastro-Enterol. Belg., 29: 631-9(May-June 1966). (In French).

Gastrointestinal lesions resulting from radiotherapy are re-

viewed, with 29 references. Clinical signs, endoscopic and radiological findings, and histological changes in the lesions are described for rectum, colon, small intestine, and stomach. Most rectal lesions were found to be caused by x ray, Ra, and ^{60}Co therapy of uterine cervical cancer, where they accounted for 1% to 17% of the cases. Recommended treatment included vitamin A and hydrocortisone. Radium therapy for uterine cervical cancer was found to cause most cases of lesions of the small intestine, although some resulted from intraperitoneal introduction of ^{198}Au or ^{90}Y. However, these lesions occurred in only about 0.6% of all irradiated cases. Treatment of these lesions was generally unsatisfactory. Irradiation damage to the stomach and small intestine was found in the form of gastric, duodenal, and jejunal ulcers which were usually only transient. Acute doses of irradiation can produce serious gastrointestinal lesions. Incidence of accidental irradiation damage varied with the dose received, some cases terminating fatally. Radiation injury in whole-body irradiation for leukemia was generally less severe and in most cases temporary. It was found that there was often difficulty in differential diagnosis between recurrent tumors and those caused by radiotherapy. Treatment of radiation injury was almost exclusively symptomatic. (BBB)

2551 RADIATION PROCTITIS WITH FISTULOUS FORMATION. Black III, W. C.; Ackerman, L. V. Cancer Seminar, 3: 129-32 (Fall 1963).

Clinical and histopathologic aspects of radioinduced bowel injury are presented. The patient was a 77-year old woman, who complained of melena, cramping abdominal pains, and of a 12-lb weight loss, 18-yr after she had received external irradiation and intracavitary Ra therapy for carcinoma of the endometrium. She was again irradiated five yr later when a recurrence took place. Rectal stricture developed into stenosis by 1962. On examination there was evidence of marked radiation effects of the skin; the rectal mucosa appeared friable. A resection of the rectosigmoid was done. The bowel showed a circumferential ulcer extending into the wall and subserosal connective tissue. Histological appearance of the biopsied tissue is described. There was an inflammatory reaction throughout this area that was exposed to radiation. The radiation effects on the bowel were evident. There were mucosal ulcerations and necrosis and extensive telangiectasis in the submucosa. Many of the vessels showed marked intimal proliferation and evidence of organized thrombosis. The muscle coats showed degeneration and hyalinization. These glandular spaces in the wall could be tracts of a diverticulum produced by radiation necrosis and superimposed infection. (BBB)

2552 ON THE STUDY OF A RADIOACTIVE SUBSTANCE FIXED IN THE BODY THOROTRAST AND CARCINOGENESIS. Ookawara, Shigeyuki; Ito, Miwako; Hirano, Yaeko (Nagasaki Univ.). Nagasaki Igakkai Zasshi, 40: 598-602 (Aug. 1965). (In Japanese).

As a result of extensive use of Thorotrast (ThO_2) during the period 1930 to 1945 for contrast studies on blood vessels, spleen, and other organs, various disorders in these organs and carcinogenesis have been reported. Among 130 cases of cancer induced by Thorotrast, liver sarcoma occurred in 41 cases, liver tumor 19, kidney cancer 16, lung cancer 7, breast cancer 3, intestinal cancer 3, abdominal cancer 5, uterine cancer 2, leukemia 12, and all other types 22. Malignant bone tumors were not observed. The average latent period for carcinogenesis with Thorotrast was 18.7 yr while with liver cancer it was 19.8 yr and in other organs was 18.4 yr. Correlation of the frequency of cancer and dose of Thorotrast injected showed that incidence of liver cancer was increased with the increase of dose and was highest in the patients injected with 60 to 80 ml. However, there was no correlation between the frequency and dose for cancers of other organs. The sex ratio for carcinogenesis in organs other than liver was 1:1. However, liver tumors in females were 3 times higher in incidence than in males. Carcinogenesis with Thorotrast is considered to be due to the ^{232}Th fixed in the organs and of α, β, or γ radiation from its daughter products. The mean expectation of life in Thorotrast-administered patients was about 5 yr lower than that of controls in 1962. (BBB)

2553 RADIOTHERAPY IN THE TREATMENT OF CANCER OF THE BLADDER. Bloedorn, Fernando G.; Wizenberg, Morris J.; Seydel, H. Gunter; Light, John P. (Univ. Hospital, Baltimore). S. Med. J., 60: 539-44 (May 1967).

Only supervoltage energies of radiation should be considered for external irradiation of bladder tumors. With the proper use of supervoltage irradiation and suitable management, in most cases the patients can tolerate irradiation for cancer of the bladder with only a mild cystitis, diarrhea, or proctitis. The rate of complications is low except in advanced cases. The normal bladder tolerates large amounts of irradiation which are in the range of cancerocidal doses for tumors. In almost all instances, transient cystitis of variable intensity will occur, but severe cystitis, contracted bladder, and ureteral or urethral structure is considered a complication of the treatment. Severe cystitis and retracted bladder occur most frequently in patients having factors which enhance the reaction to radiation. These factors are: surgical procedures performed within 3 weeks prior to the beginning of radiation therapy (transurethral resection, multiple biopsies with cauterization, suprapubic cystostomy, or segmental resection); obstruction of the bladder neck, prostatic hypertrophy, or urethral obstruction; infection; multiple cauterizations before therapy; extensive ulcerating tumors where a combination of the previous factors is present; and invasion of bladder neck by cancer, even in the absence of obstruction. These factors were found to be present in more than 75% of patients with severe cystitis or contracted bladder. Severe reactions can be avoided by a minimum delay of one month between the surgical procedures and the beginning of irradiation. Infection can be corrected by the use of antibiotics and elimination of obstruction prior to the treatment. Bilateral obstruction of the ureters, even if very slight on one side, should be relieved by diversion before treatment is started; unless this is done the obstruction rapidly becomes complete with the initiation of radiotherapy and leads to ascending infection with loss of renal function and consequent death. (BBB)

2554 POSTIRRADIATION BONE LESIONS IN PATIENTS SUBJECTED TO RADIOTHERAPY FOR MAMMARY CANCER. Lattuada, Angelo; Severini, Aldo (Univ., Milan). Tumori, 52: 401-20 (1966). (In Italian).

The radiographic patterns of postirradiation bone lesions in eight patients treated for breast cancer are described. Rib fractures, often multiple, at the anterior portion of the rib were observed in all patients. Two also showed lesions of the shoulder-blade, with a lesion in the humeral diaphysis in one. Only some of the eight patients were heavily irradiated in terms of the total dose, diameter of the fields, and dose fractionation. In these cases the lesions were more severe and larger in comparison with those in the other patients. Bone repair and reconstruction were not observed even many years after initial treatment. Regions of overdosage in some bone structures may have occurred also in the other cases, where the usual therapeutic dose limits were not exceeded. This overdosage was likely due to the particular geometric relations between neoplastic foci and the thoracic wall, requiring several irradiation fields. From the radiographic point of view, rib fractures are difficult to detect in the earlier phases; therefore, differential diagnosis has to be made from traumatic fractures. Later their recognition becomes easier, though occasionally the problem of differentiation from possible metastatic foci may arise. (BBB)

2555 RADIATION AND OTHER ENVIRONMENTAL FACTORS IN HUMAN BIOLOGY. Dobson, R. Lowry (World Health Organization, Geneva). pp 1011-20 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

The changing circumstances of human life, the external and internal influences, and the effect of these influences on the biology of man are discussed; the effect of radiation exposure is included. (B.H.S.)

2556 EFFECT OF LIGHT, TEMPERATURE, AND GAMMA RADIATION ON THE LOCOMOTOR ACTIVITY OF JUVENILE STEELHEAD TROUT (SALMO GAIRDNERI). Lichtenheld, Richard William. Seattle, Univ. of Washington, 1966. 254p. Thesis.

Juvenile steelhead trout were exposed to either long (18L), natural (NL) or short (6L) daily photoperiods, each in combination with naturally varying water temperatures, for eighteen months beginning in mid-January 1962. The basic measures employed were spontaneous locomotor activity and body coloration (i.e., tendency to silver). In all, a total of 150 groups of five fish each were tested and examined. Natural day length fish exhibited a bimodal yearly pattern of locomotor activity with peaks in the spring (general down-stream migration period) and late fall. The resulting activity-temperature relation (scope of activity) of NL fish was diphasic, peaking at the intermediate temperature of 13.2°C. Long and short day length fish displayed unimodal yearly activity patterns with maximum responses occurring in the summer and winter months respectively. Artificial constant 18L and 6L conditions thus shifted the optimum response conditions to those temperature levels that a given photoperiod is normally associated within nature. Long photoperiods increased the rate of the smoltification process; short photoperiods delayed it. The combined photoperiods effects indicated that the daily photoperiod is the primary environmental factor regulating the preparatory phase of the seaward migration in juvenile steelhead. Measures of the photoresponsiveness of one and two year old steelhead to night and twilight light intensities, together with

24-hour rhythm studies, suggested that the bimodal nature of the daily activity pattern (one day and one night peak) is the mechanism responsible for the characteristic nocturnal activity of migrant steelhead smolt. Associated with the yearly variations in activity levels was a seasonal sensitivity to low level gamma radiation. Placement of either an inactive or radioactive cobalt tag (16 μc) in the fish 16 to 17 hours prior to testing lowered activity levels in the winter. The inactive tag had no significant effect during the remainder of the year. Cobalt 60 tags, however, increased activity levels at the intermediate temperatures (9° to 15°C) of the spring and late fall months. The significance of this increased sensitivity to external stimulation and its relation with the smolt stage, is discussed in relation to the downstream migration of steelhead and salmon. It is suggested that this freshwater phase of the life cycle represents a sensitive, imprinting period during which the cues, enabling the fish as an adult to locate its home, are learned. In view of the interpreted importance of the seaward migration period to the subsequent homing ability of maturing adults, it is proposed that the mechanism or sense underlying the cuing system used by returning adults be called imprint-location. (auth)

Radiation Effects on Plants

Refer to abstracts 2483, 2494, 2498–2500, and 2502.

Radiation Effects on Microorganisms

Refer also to abstract 2547.

2557 MICROORGANISMS EXPOSED TO IRRADIATION IN THE WATER CIRCUITS OF THE ATOMIC REACTOR AT CSILLEBERC. Hortobagyi, Tibor; Vigassy, Jozsef (Univ. of Agrarian Sciences, Godollo, Hungary. Central Research Inst. of Physics, Budapest). Biol. Kozlem., 14: 113-20(1967). (In Hungarian).

Live microorganisms were detected in the irradiated waters of the experimental atomic reactor at Csilleberc that has an output of 2.5 MW; the organisms were found in the secondary water circuit, the primary circuit and also in the water tank in which burned out heating elements are stored. Four of the microorganisms present are described and their living conditions characterized. It is noteworthy that a blue alga was demonstrated also in the water of the primary circuit. (auth) (JPRS)

2558 PRELIMINARY OBSERVATIONS ON THE IN VITRO PHOTOREACTIVATION OF AN INSECT VIRUS INACTIVATED WITH ULTRAVIOLET RADIATION. David, W. A. L. (Agricultural Research Council, Cambridge, Eng.); Magnus, I. A. J. Invertebr. Pathol., 9: 266-8(1967).

Visible light partially restored the activity of certain bacteriophages and plant viruses that were inactivated by suitable exposures to uV radiation. Reactivation only occurred in these cases when the bacteria or plants already infected with the uv-irradiated virus were exposed to the visible light. It did not occur if the irradiated phage or virus, or the hosts or both, were exposed separately. Evidently, cellular structure was essential for the occurrence of this phenomenon. However, in the case of uv-inactivated Hemophilus influenzae transforming DNA, cellular structure was not necessary, and the same appeared to hold for the insect virus used in this investigation. The virus used causes granulosis disease of the European cabbageworm (or the large white butterfly) Pieris brassicae. When inactivated by exposure to uv light (250 or 260 nm) and immediately exposed to strong visible light, the virus killed many more larvae, when fed to them, than did the control virus that had only received uv radiation. The results demand a different explanation of the photoreactivation process in the case of this granulosis virus from that which has been accepted for certain phages and plant viruses. (BBB)

Radiosterilization and Radiopreservation

2559 IRRADIATION OF FISH AND FISH PRODUCTS. Houwing, H. (TNO, Ijmuiden, Netherlands). Koeltechniek, 59: 111-13(1966). (In Dutch).

Packing of irradiated fish products may be done in vacuum, or normally in either a gas-permeable or -impermeable material. The problems of bacteriological protection are considered, with chief attention devoted to Clostrodium botulinum. Fish pasteurized by irradiation must be maintained at temperatures below 5°C, and the irradiation and cooling processes taken together must be uninterrupted. Fresh haddock fillets could be maintained at 0° to 1°C for 30 days; fillets from 10-day-old fish could be maintained 20 days. Preservation at 5°C is only half as efficient. Since fish fat develops unpleasant odors and tastes on irradiation, certain kinds (cod, haddock) can be subjected to stronger irradiation than others (herring) which are oilier; the doses range between 150 to 300 krad. Oily fish must not be brought in contact with oxygen; the others should be packed in material which is impermeable to gases in order to avoid off-flavors. (BBB)

METALS, CERAMICS, AND OTHER MATERIALS

Metals and Alloys

Refer also to abstracts 2087, 2306, and 3945.

2560 (IS-RD-11) PROGRESS REPORT [ON REACTOR MATERIALS], JULY–SEPTEMBER 1967. Voigt, A. F. (ed.) (Ames Lab., Iowa). 41p. Dep. CFSTI.

A study was conducted of new and improved materials of interest in reactor development. Included in these materials are fuel and blanket metals, metals which have structural, container, or control properties of value in reactor design, and compounds and ceramics of potential use in reactors. The behavior of these materials during fabrication and the improvement in fabricability, the corrosion resistance of container metals to molten metal fuels and the nature of the attack of oxidizing atmospheres on refractory metals are topics which have direct application to reactor design. The availability of ultra-pure materials in the usual forms and as single crystals and the knowledge of the nature and amounts of residual impurities are important. (auth)

2561 NITROGEN ABSORPTION IN GAMMA IRON AND IRON–LANTHANUM ALLOYS. Segawa, Kiyoshi; Tsunetomi, Eiichi; Wada, Kaname; Takei, Koji. Seitetsu Kenkyu, No. 254, 175-9(Mar. 1966).

Solubility of nitrogen in pure Fe and in the following Fe–La alloys is determined: Fe–0.025 La, Fe–0.31 La, Fe–0.60 La, Fe–0.80 La, and Fe–1.30 La. Analysis of La is determined by the spectrophotometric method. Samples are treated in a mixed gas atmosphere at 1080 to 1350°C. The apparent solubility product of LaN is expressed in an equation which suggests that the nitride forming tendency of La is slightly weaker than that of Al and Nb in the temperature range studied. (Rev. Met. Lit.)

2562 INFLUENCE OF Zn ON THE PROPERTIES OF CREEP-RESISTING Mg–Nd–Zr ALLOYS. Tikhova, N. M.; Blokhina, V. A. Russ. Cast. Prod. (Engl. Transl.), No. 1, 39-41(Jan. 1966).

Mg–Nd–Zr alloys (1.5–3.5% Nd, 0.5–0.7% Zr) are alloyed with 0.1–1% Zn. The specimens are cast and heat treated by quenching and aging. A study is made of the effect of Zn on yield strength, tensile strength, creep rate, and creep rupture strength (at 250°C) of the as-cast and heat treated specimens. It is determined that additions of Zn have no effect on mechanical properties and creep properties in the as-cast specimens. After heat treatment, however, the mechanical and heat resistant properties are considerably improved. Data are given on solidus and liquidus points of the alloys, depending on concentrations of Nd, Zr, and Zn. Also given are weldability and corrosion resistance of the tested alloys. (Rev. Met. Lit.)

2563 RARE METALS AND THEIR ALLOYS AS MATERIALS FOR MODERN TECHNOLOGY. Wagner, M. Gunter. Trait. Therm., No. 23, 47-50(Sept.-Oct. 1966). (In French).

Mo, Nb, and Re are studied, stressing mechanical properties, modes of production, and applications in modern technology. The melting point of Mo is 2662°C. Mo provides better resistance to heat and corrosion when added to steels. Mo filaments are used in glass as current conductors. Nb melts at 2470°C. Large ingots of Nb can be prepared from powder in arc melting furnaces and electron jets. Nb alloys give good heat resistance below 1300°C. Re melts at 3180°C. At high temperatures Re is attacked by oxygen in air, but not by nitrogen or hydrogen. Additions of Re diminish brittleness of W and Mo. (Rev.Met.Lit.)

2564 VIBRATORY COMPACTING. PRINCIPLES AND METHODS. PERSPECTIVES IN POWDER METALLURGY. FUNDAMENTALS, METHODS, AND APPLICATIONS. VOLUME 2. Hausner, Henry H.; Roll, Kempton H.; Johnson, Peter K. (eds.). New York, Plenum Press, 1967. 309p. $17.50.

Part I of this volume is a translation of the Russian book Fiziko-khimicheskie Osnovy Vibratsionnogo Uplotneniya Poroshkovykh Materialov.

The method of pressing powdered materials using vibratory compacting is described. The technological and economic advantages of this method over static pressing methods, especially when dealing with the powders of very hard and strong materials, such as carbides, borides, ceramics, and ferrites, are pointed out. This method of processing makes possible the production of high-strength, heat-resistant, and heat-stable parts directly from the powder. An annotated bibliography on vibratory compacting containing 64 references is included. (R.C.K.)

Corrosion and Erosion

Refer also to abstract 2619.

2565 (AECL-2776) OXIDATION OF ZIRCONIUM–ALUMINUM ALLOYS. Cox, B. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). Oct. 1967. 24p. Dep. CFSTI. CAN $1.00.

Examination of the processes occurring during the oxidation of Zr–1% Al, Zr–3% Al, and Zr–1.5% Al–0.5% Mo alloys has shown that in steam rapid oxidation occurs predominantly around the Zr_3Al particles, which at low temperatures appear to be relatively unattacked. The unoxidized particles become incorporated in the oxide, and become fully oxidized as the film thickens. This rapid localized oxidation is preceded by a short period of uniform film growth, during which the oxide film thickness does not exceed ~200 Å. Thus the high oxidation rates can probably be ascribed to aluminum in solution in the zirconium matrix, although its precise mode of operation has not been determined. Once the solubility limit of aluminum is exceeded, the size, distribution, and number of intermetallic particles affect the oxidation rate merely by altering the distribution of regions of metal giving high oxidation rates. The controlling process during the early stages of oxidation is electron transport and not ionic transport. Thus, the aluminum in the oxide film is presumably increasing the ionic conductivity more than the electronic. The oxidation rates in atmospheric-pressure steam are very high and their irregular temperature dependence suggests that the oxidation rate will be pressure dependent. This was confirmed, in part, by a comparison with oxidation in moist air. It was found that the rate of development of white oxide around intermetallic particles was considerably reduced by the decrease in the partial pressure of H_2O; the incubation period was not much different, however. (auth)

2566 (AECL-2777) RATE CONTROLLING PROCESSES DURING THE OXIDATION OF ZIRCONIUM ALLOYS. Cox, B. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). Oct. 1967. 23p. Dep. CFSTI. CAN $1.00.

A study of the potentials developed across growing oxide films on zirconium alloys, and I-V curves produced by polarizing these specimens during oxidation, has shown that quantitative interpretation of the potentials in terms of a rate controlling process is not possible at present. Qualitative interpretations of the results have shown how the rate controlling process may be affected by the presence of alloying elements in the form of intermetallic particles, and by changes in the experimental conditions. (auth)

2567 (EURAEC-1918) QUARTERLY REPORT NO. 17 [ON CORROSION OF STAINLESS STEEL], JANUARY 1–MARCH 31, 1967. Chaudron, G. (Centre National de la Recherche Scientifique, Paris (France)). Contract 059-65-1-TEEF(RD). 21p. (EUR-3400). Dep. CFSTI.

Work Performed under United States–Euratom Joint Research and Development Program.

The influence of very small quantities of carbon on the corrosion by superheated steam is studied. Results indicate that the alloys with the lowest carbon content ($20 \text{ to } 30 \cdot 10^{-6}$) are sensitive to intergranular penetration of the oxide. The influence of platinum additions in stainless steels on the resistance to corrosion by superheated steam is studied. The presence of platinum reduces the absolute value of the corrosion rate, but at 600°C this may cause a slight sensitivity to intergranular corrosion. Stress corrosion results for boiling magnesium chloride shows that this corrosion is associated with the formation of a passive film. Potentiokinetic curves plotted in magnesium chloride at 154°C show the great capacity of stainless steel for passivating in such a medium (18/10 and 20/25 steels, Ni 80%–Cr 20% alloy). The formation of a passivation film on stainless steel samples immersed in boiling magnesium chloride was also established by using electron diffraction. (J.C.W.)

2568 (N-67-16673) CONTAMINATION EXPOSURES OF COLUMBIUM AND TANTALUM ALLOY SPECIMENS. Final Report, February 25, 1965–June 15, 1966. Fleming, R. B. (General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section). July 15, 1966. Contract NAS3-4169. 135p. (NASA-CR-54934). CFSTI.

The program described was conducted to determine the oxidation rate, or gettering rate for oxygen, of niobium, zirconium, and tantallum alloy specimens under conditions of low pressures and

high temperatures. A total of 15 exposures were conducted with oxygen partial pressures at levels ranging from about 10^{-5} torr to 5×10^{-8} torr, 885, 950, 980, and 1100°C. The gettering rates were established by measuring the pressure drop across a known flow conductance, from which the oxygen gas mass flow rate (equal to the gettering rate) was computed. Data on the pressure directly over the specimen and the gettering rate, were used to calculate the sticking factor (that fraction of total molecules striking the specimen, which do not rebound), which was of primary interest in these experiments. In addition to the 15 exposures, several experiments were conducted to determine various pressure gage characteristics, and an analysis was made of pressure distribution throughout the system. (auth)

2569 (NAA-SR-Memo-12005) COMPATIBILITY OF BRAZE ALLOYS WITH MOLTEN LITHIUM HYDRIDE. Welch, Frank H. (Atomics International, Canoga Park, Calif.). June 7, 1966. 11p. Dep. CFSTI.

Two brazing alloys were tested for compatibility with molten lithium hydride at 1300°F. One alloy, Haynes Stellite #157 alloy, successfully withstood 100 hours of exposure. Testing was continued for 4,000 hours. Corrosion to about .004 in. depth was noted in the brazed zone. It was concluded that the brazing alloy exhibited excellent corrosion resistance, and could have withstood 2,000 or more hours of exposure before failure. It was recommended that the Haynes Stellite #157 braze alloy be considered in future shield fabrication problems where welding presents difficulties. (auth)

2570 KINETICS OF THE OXIDATION OF THULIUM BY OXYGEN AND WATER VAPOR. GAS–METAL REACTIONS. Svec, H. J.; Rider, T. J. (Ames Lab., Iowa). J. Less-Common Metals, 14: 103-12(1968).

Thulium metal was reacted with oxygen, water vapor, and mixtures of the two in the temperature range 650 to 850°C at varying gas pressures. A gravimetric study of the oxygen and water vapor reactions showed that they follow a parabolic rate law, although there was some indication of a linear law at 650°C and a cubic rate law at 850°C. Analysis of the reaction products showed them to be Tm_2O_3 for both gases with the evolution of hydrogen in the water vapor reaction. Activation energies of 28.0 and 29.0 kcal/mole were found for the oxygen and water vapor reactions, respectively, indicating a similar mechanism for the two reactions. The reaction between thulium and mixtures of oxygen and water vapor was found to be more complex, apparently depending upon the microstructure of the metal samples used, as well as impurities present. In some cases a highly accelerated rate was noted between 730 and 770°C with the subsequent formation of a non-adherent coating. Since this did not occur at temperatures above or below this range, this is attributed to a change in structure in the coating. (auth)

2571 ANALYSIS OF MODIFIED SILICIDE COATINGS FOR OXIDATION PROTECTION OF COLUMBIUM AND TANTALUM. Lublin, Paul (General Telephone and Electronics Labs., Bayside, N. Y.); Sama, L. Amer. Ceram. Soc. Bull., 46: 1083-90 (Nov. 1967).

Binary and ternary coatings in the Ti–Cr–Si system on niobium and tantalum substrates were exposed to oxidizing or argon environments at 2000, 2500, and 2800°F for times up to 100 hr and then analyzed by metallographic, x-ray diffraction and electron probe techniques. By correlating data from the analytical techniques the oxide and intermetallic phases were identified and their distribution noted in the coatings. Changes in coating behavior are discussed with reference to the analyses. (auth)

2572 THE CORROSION BEHAVIOR OF THE NICKEL-BASE ALLOY INCONEL-625. Borgstedt, Hans Ulrich (Gesellschaft fuer Kernforschung mbH, Karlsruhe, Ger.). Werkst. Korros., 17: 1027-33(Dec, 1966). (In German). KFK–535.

The high temperature stable Ni-base alloy Inconel-625 shows in corrosion studies a high corrosion resistance in reactor coolant media such as Na and water vapor. The scaling stability up to over 800°C can be characterized as very good and the alloy is relatively stable against chemical attack in the non-passive region. There is no susceptibility to intercrystalline reactions with aqueous electrolytic solutions. In liquid Na at 600°C in a research installation designed to test isothermal chemical mass transport, a precipitation of crystallites of a new phase occurs at the grain boundaries when an austenitic 18/8 Cr–Ni steel is in contact with liquid Na and Inconel-625. (tr-auth)

2573 COMPATIBILITY OF TYPE-304 STAINLESS STEEL WITH SODIUM PASTE REACTOR FUELS. Chasanov, M. G. (Argonne National Lab., Ill.). Nucl. Sci. Eng., 30: 310-11 (1967).

Paste fuels appear to offer potential economic advantages for use in fast-breeder reactors. In recent years, such systems have been proposed for use in both core and blanket regions. The results of static corrosion tests of the compatibility of type-304 stainless steel with Na pastes prepared from each of the leading ceramic fuel materials— UO_2, UC, and UN—are presented. The pastes were prepared by heating ACS Reagent Grade sodium in a type-304 stainless-steel corrosion capsule together with weighed amounts of the ceramic material; all manipulations were carried out in a He glovebox. A degreased coupon of type-304 stainless steel was then inserted into each capsule, and the corrosion test capsules were welded closed in the He glovebox. All the corrosion test capsules were held at 1400°F for 1000 hr in a resistance heated furnace and allowed to cool in the furnace. The capsules were then opened in the He glovebox; the corrosion coupons were removed, washed with butanol, and examined using x-ray diffraction, electron microprobe, and metallographic techniques. Portions of the test coupons were submitted for chemical analyses. (auth)

2574 THE CREEP-RUPTURE STRENGTH OF MOLYBDENUM COMPOSITE CAST WITH NIMONIC 90 ALLOY. Yoda, Rempei; Arai, Takashi. Nippon Kinzoku Gakkaishi, 31: 90-4 (1967). (In Japanese).

Because Mo, which is a typical refractory metal, has poor oxidation resistance, but high strength at elevated temperatures, it cannot be used at high temperatures in air. A new coating method was devised to use Mo under the above-mentioned condition. According to this method, commercially pure Mo rods are covered with Nimonic 90 Ni-base alloy which is hot workable and oxidation resistant and forge-worked. After the composite cast materials are hot swaged, they are creep rupture tested at 1000°C with a stress of 5 to 10 kg/mm² in air. It is possible to work the hard and brittle diffusion zone formed in the interface between Mo and the covering alloy without cracking. It is possible to heat and work Mo freely in air, and to make the materials stable by the following working, even if the discontinuities in bonding were formed when Mo was compositely cast with Nimonic 90 alloy. The creep-rupture strength of the composite cast materials at 1000°C in air is improved to a great extent as the part of the Mo core is increased, while the effect on the strength is negligible when the Mo core is small. The creep-rupture strength of these materials depends on the area of both Mo and diffusion zones, and the strength for this area is comparable to the strength of Mo under the same condition in vacuum. From this result, it is indicated that the new coating method, using Nimonic 90 alloy can protect Mo perfectly from the oxidation at elevated temperatures in air. (Rev. Met. Lit.)

2575 CORROSION KINETIC STUDIES BY THE RADIOACTIVE METHOD. I. Imre, L.; Konya, J. (Kossuth Univ., Drebrecen, Hungary). Acta Chim. Acad. Sci. Hung., 53: 219-40(1967).

In galvanic corrosion, as in other dissolution and precipitation processes, the free enthalpy of the transitional layer that is characteristic of the solid-liquid phase boundary plays a significant part in determining the rate. The free enthalpy of the transitional layer expresses the difference in activity of the substance on the metal surface from unity; this difference can be calculated from the departure of the morphological parameter of the experimentally determined ion adsorption isotherm from the value predicted by Langmuir's theory. The corrosion-polarization and corrosion–kinetic parameters calculated in this way for the corrosion systems $Ag/Ag^+ - Pt$ and $Cu/Cu^{++} - Pt$ are in fair agreement with the experimental values. (auth)

2576 WEAR AND COMPATIBILITY BEHAVIOR OF LIQUID METAL BEARING MATERIALS. Wallace, M. J. (Pratt and Whitney Aircraft, East Hartford, Conn.). J. Lubric. Technol., 89: 466-72(Oct. 1967).

The wear and compatibility characteristics of selected bearing materials, including surface coatings and cemented refractory carbides were investigated in support of a pump development program for advanced Rankine cycle space power plants employing high temperature lithium and NaK. Compatibility of candidate materials with 1100°F lithium in Nb-1 Zr alloy was studied in tilting capsule tests for durations to 7000 hr. The wear behavior of material combinations was evaluated with a rotating disk-static assembly in lithium and NaK to 1000°F. The best compatibility and wear characteristics were exhibited by high density molybdenum cemented carbides. Carburized Nb-1 Zr alloy wear resistance was inconsistent but, under the best conditions was nearly equivalent to that of the cemented carbides. Plasma sprayed coatings of tungsten carbide and WC–Co gave encouraging results in NaK, but additional development of the coating process appeared necessary to assure reliable control of adhesion and performance. (auth)

2577 CORROSION AND OXIDATION. Waber, J. T. (Los Alamos Scientific Lab., N. Mex.). pp 145-89 of Plutonium

Handbook. A Guide to the Technology. Vol. I. Wick, O. J. (ed.). New York, Gordon and Breach Science Publishers, 1967.

Information available on the corrosion and oxidation of Pu and its alloys up to February, 1964 is presented. The general properties of Pu, both the low and high temperature corrosion and oxidation of Pu and its alloys, and the ignition and pyrophoricity of Pu and its alloys are discussed. The corrosion data for various atmospheres is presented. Because the corrosion and oxidation behavior of Pu and its alloys is not completely understood, a large number of experimental graphs and observations are included. (48 references) (B.L.M.)

2578 INVESTIGATIONS OF THE STRESS-RUPTURE AND CREEP BEHAVIOR OF BINARY AND TERNARY VANADIUM ALLOYS. Bohm, H.; Schirra, M. J. Less-Common Metals, 12: 280-93(Apr. 1967). (In German).

The creep and stress-rupture behavior of binary V–Ti and ternary V–Ti–Nb alloys were studied in the temperature range 650 to 800°C. A strong influence of the Ti content on the creep and stress-rupture properties was found in the binary alloys as well as in the ternary alloys. At Ti concentrations above 5% the stress-rupture strength is lowered with increasing Ti content, whereas the ultimate tensile strength at the same temperature shows an increase with increasing Ti content. The activation energy for creep of pure V in the temperature range 650 to 800°C corresponds to the activation energy of diffusion; with increasing Ti content of the alloy the activation energy for creep at first decreases and then increases to more than 100 kcal/g-mole at a Ti concentration of 20%. The stress exponent for creep at 650°C has a maximum at about 5% Ti. No influence of the Nb content on the activation energy and the stress exponent could be found. All alloys show a transgranular fracture. (Rev. Met. Lit.)

2579 OXIDATION OF ZIRCALOY-2 AT 600 TO 800 C. Fukushima, Eiji. Nippon Kinzoku Gakkaishi, 30: 910-15(1966). (In Japanese).

Several studies have been done on the peculiar oxidation of Zr and its alloys, mostly by measuring the weight increase during oxidation and the oxygen concentration gradient in the substrate. To obtain a better understanding of the oxidation of Zr and its alloys, it is more adequate to separate the total weight increase into the formation of oxide scales and the oxygen solution into the substrate. The growth of oxide scale formation is estimated from the measurement of the electric capacity. The relative importance of the oxide scale formation in the total oxidation is investigated and consideration is given to the substantial portion of oxygen solution dissolved into the substrate. Main results of this study are as follows: the oxidation of Zircaloy-2 at 600 to 800°C is proportional to the cubic root of oxidation time until the breakaway occurs. According to the electric capacity measurement of specimens, the increase of the oxide scale thickness is also nearly proportional to the cubic root of oxidation. The higher the oxidation temperature, the more oxygen dissolves into the substrate. According to the radiochemical analysis of the amount of oxygen dissolved in the substrate at 800°C, the contribution of the oxide scale formation to the total weight grain is 93 to 95% in the initial period of oxidation (within 70 to 100 min). Thereafter, the contribution of the dissolved oxygen increases rapidly and that of the oxide scale formation does not increase so much. (Rev. Met. Lit.)

2580 OXIDATION-RESISTANT HARD MATERIALS. Morgenthal, Jutta. Neue Huette, 11: 484-90(Aug. 1966). (In German).

The elevated-temperature properties of hard material—the intermediate compounds of transition elements of Groups IV, V and VI of the periodic system with C, B, N or Si are reviewed. The oxidation resistance of titanium carbides, chromium carbides and zirconium carbides, nitrides, borides and silicides under various conditions and at various temperatures, with different percentages of binder metals, are reviewed. The experiments show that sintered parts of CrC with Ni as the binder may be used to 1100°C and with short-time exposures to 1200°C. If specimens annealed at 1000°C are quenched in ice water, the oxide layer formed adheres permanently. No changes are observed after 100 cycles of alternating exposure for 5 min to 1000°C, followed by 2 min in a cold air blast. Oxidation resistances of commercial compositions are tabulated, together with a comparison of the corrosion resistance in acids and NaOH of chromium carbides with other hard materials and 18-8 stainless steel, physical properties of the materials and characteristics of various hard material systems. (Rev. Met. Lit.)

2581 RESEARCH INTO THE OXIDATION OF NIOBIUM ALLOYED WITH VANADIUM, TITANIUM, AND ZIRCONIUM. Prokoshkin, D. A.; Vasil'eva, E. V.; Lazarev, E. M. pp 285-90 of Svoistva i Primenenie Zharoprochnykh Splavov. Moscow, Nauka, 1966. (In Russian).

The oxidation of Nb alloyed with 1 to 15% V, 1 to 10% Ti and 1 to 20% Zr in air at 900 to 1200°C has been investigated. During the initial period, oxidation follows a parabolic curve, which then becomes almost linear. As the V content of the ternary alloy is increased, the oxidation rate passes through a minimum, and as the Zr content is increased it passes through a maximum. The alloy containing 5% V and 10% Ti had the best resistance of oxidation. The relationship of the oxidation rate to the temperature is expressed by an Arrhenius equation. The activation energy depends on the composition of the alloy. The scale on the ternary alloys consists of a solid solution of V and Ti in rho Nb_2O_5. (Rev. Met. Lit.)

2582 REFRACTORY METALS: PROTECTION BY ALUMINUM–TIN COATINGS. Tin Uses, No. 71, 8-9(1966).

Intermetallic Al–Sn coatings have been successfully applied to Nb alloy specimens by a slurry process. Exposure to slowly moving air at 1090 to 1370°C shows that the 25 Al–75 Sn coating has the most oxidation resistance. Tests under simulated thermal reentry environments show that 30% of the coating weight is lost after 10 min exposure. Microstructures are shown. (Rev.Met.Lit.)

2583 CORROSION OF ZIRCONIUM IN MOLTEN CHLORIDES OF ALKALI METALS. Volodin, V. P.; Ozeryanaya, I. N.; Smirnov, M. V. pp 77-81 of Electrochemistry of Molten and Solid Electrolytes. Vol. 3. New York, Consultant's Bureau, 1966.

Data are presented on the corrosion of Zr in a molten equimolecular mixture of NaCl–KCl free from traces of oxygen and in an argon atmosphere. The procedure for direct measurement of corrosion rate by the weight loss in a melt of given chemical composition is described. The rate of corrosion of Zr is shown to increase with increasing temperature and is calculated from the value of the steady potential. Anodic polarization of Zr is measured at 700, 800, and 900°C at current densities of the polarizing current between 10^{-5} and 0.1 amp/cm^2. Within the experimental error, the corrosion rate determined by the direct method is in good agreement with the corrosion rate calculated from the values of steady potential and from the anodic polarization curves. (Rev. Met. Lit.)

2584 HIGH-TEMPERATURE CORROSION RESISTANCE OF CHROMIUM ALLOYS WITH ZIRCONIUM. Guts, A. V.; Tumarev, A. S. Tr. Leningrad. Politekh. Inst., No. 251, 76-81(1965). (In Russian).

The oxidation of alloys containing up to 24% Zr was carried out in oxygen at 1100 and 1200°C. At up to 5% Zr, the oxidation was parabolic and the oxidation rate did not depend on the Zr content. With a further increase in the Zr content in the alloy, the oxidation was linear and the increase in the oxidation rate was proportional to the content of Zr. ZrO_2 and alpha Cr_2O_3 were detected in the scale. At a low Zr content in the alloy its quantity in the scale was small and the diffusion processes were the same as those in the scale on pure Cr. At a large quantity of Zr in the alloy its content in the scale also increases. In this case the presence of ZrO_2 with anion defects promotes the diffusion of oxygen and an increased oxidation rate. (Rev.Met.Lit.)

2585 OXIDATION RESISTANCE OF Kh20N80 ALLOY, ALLOYED WITH LANTHANUM AND CERIUM. Ivanov, E. G.; Opara, B. K.; Filippov, A. F. Izv. Vyssh. Ucheb. Zaved., Chern. Met., No. 7, 77-9(July 1966). (In Russian).

The effect of La (0.001–0.148%) and Ce (0.001–0.16%) on the oxidation resistance of Kh20N80 alloy in air atmospheres at high temperatures was investigated. The metal was induction melted and cast into molds 2 min after adding the rare-earth metals. In another series of melts, the metal was poured into molds 4, 8, and 12 min after adding La and Ce. Oxidation kinetics was studied at 900, 1000, 1150, and 1200°C for 2 hr by periodic weighing of specimens without removing them from the reaction zone of the furnace. Longer tests, 200 hr, were made at 900°C. After oxidation, specimens were studied by x-ray structural analysis and by microscopic analysis of the oxidized layer. Oxidation rate decreases with time. Only the oxide (Cr_2O_3) was observed in the oxide films. Volatility of Cr_2O_3 from the oxide film significantly decreases when Ce content in the alloy is increased. Oxidation resistance of Kh20N80 alloy improves when it is alloyed with La and Ce. (Rev.Met.Lit.)

2586 COMPREHENSIVE CAVITATION DAMAGE DATA FOR WATER AND VARIOUS LIQUID METALS INCLUDING CORRELATIONS WITH MATERIAL AND FLUID PROPERTIES. Garcia, Ramon. Ann Arbor, Mich., Univ. of Michigan, 1966. 422p.

Thesis.

The cavitation-erosion phenomenon is analyzed by developing a relationship between the damage incurred in a flowing venturi device

and the damage obtained in the accelerated vibratory facility. A high-temperature ultrasonic vibratory device was used. The experimental studies carried out with the vibratory facility indicated that the tantalum-base alloys, T-111 and T-222(A), were the most cavitation resistant of the materials tested in lead-bismuth alloy at 500 and 1500°F, in mercury at 500°F, in water at 70°F, and in lithium at 500 and 1500°F. The stainless steels were the most resistant in mercury at 70°F. All materials tested in lead-bismuth sustained greater damage at 1500 than at 500°F. All materials tested in mercury sustained greater damage at 500 than at 70°F. In lithium the damage suffered by a material at 1500°F was much less than that at 500°F. This is due primarily to thermodynamic effects which are important in lithium at 1500°F. Computer correlations of the cavitation damage data with selected mechanical and fluid properties indicate that there is no single material mechanical property which can be used to correlate the damage with good precision, even if coupling parameters to account for fluid property changes are included in the correlation. A simple comprehensive correlating equation involving only the ultimate resilience of the material and fluid density is expressed. Direct comparison of flowing system (venturi) and vibratory results shows that the rankings of materials for cavitation damage are quite similar, but that the relative ratios between different materials are much greater in the venturi facility. This indicates the feasibility of the accelerated vibratory results in interpreting cavitation experiments in flowing systems. (TCW)

Preparation and Fabrication

Refer also to abstracts 2020, 2274, 2284, 2286, 2574, 2635, and 3212.

2587 (BNWL–553) APPLICATION OF SPUTTERING TO THE FABRICATION OF NEUTRON DETECTOR ANODES. McClanahan, E. D.; Moss, R. W.; Busch, R. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Nov. 1967. Contract AT(45-1)-1830. 17p. Dep. CFSTI.

Triode sputtering was selected for application to a fabrication process. The sputtering process is discussed in terms of the variables and techniques available to obtain desired product characteristics. Some problems that are encountered in the application of sputtering to fabrication are considered. An experimental project concerned with the fabrication of neutron detector anodes is reported as an example of the application of the sputtering process. The anodes, which consisted of uranium coated stainless steel cylinders, were successfully produced by this technique. (auth)

2588 (NLCO–991) ROTARY PIERCING OF URANIUM. Hesselbrock, H. W.; Davis, H.; Polson, C. E. (National Lead Co. of Ohio, Cincinnati). Oct. 1967. Contract AT(30-1)-1156. 53p. Dep. CFSTI.

Uranium billets were rotary-pierced in the high alpha temperature range on a modified three-roll No. 1 Witter mill. Rolled and extruded billets were used as feedstock. They were heated in a muffle furnace under a protective atmosphere of argon. Evaluations were made of the effects of billet preheat temperature, roll pass design, piercing point design and material, mill settings, roll speed, roll cooling, and type of feedstock. Problems with eccentricity and undesirable grain structures experienced in previous tests were corrected. Pierced uranium tubes were produced having uniform, fine grain structures, smooth surfaces, and acceptable dimensional variations. (auth)

2589 (WAPD-Trans–75) THE PRODUCTION OF FUEL ELEMENTS IN FRANCE. Translated for Bettis Atomic Power Lab., West Mifflin, Pa., from Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), No. 63, 12-20(1967). 26p. Dep. CFSTI. JCL $2.60 fs, $1.01 mf.

The industrial production of metallic uranium/graphite, oxide, and laminated fuel elements in France is discussed. The capacity, economy, fabrication techniques employed, and testing during production of each type are described. (F.S.)

2590 ELECTRODEPOSITED COMPOSITE COATINGS FOR WEAR RESISTANCE. Kedward, E. C.; Kiernan, B. Metal Finish. J. (London), 13: 116-18; 120(Apr. 1967).

Electrodeposited coatings are of interest primarily for wear or high-temperature applications. Coatings can be formed on all substrates that can normally be electroplated. Those substrates on which composite coatings have been formed with satisfactory adhesion to date are stainless steel, Nimonic alloy, tool steel, Mo, Ta, W and Cu. A coating thickness up to 0.030 in. can be obtained. The wear resistance properties of Ni-based composite coatings on stainless steel substrate are being measured. Hardness and adhesion values have been determined. The coatings are chromium carbide, alumina, silicon nitride, zirconium dioxide, boron nitride, chromium oxide, zirconium diboride, titanium carbide, silicon carbide, tantalum carbide, zirconium carbide and tungsten carbide. Typical microstructures of the coatings are illustrated. (Rev. Met. Lit.)

2591 WELDING OF THE CONTROL PLATES FOR THE HIGH FLUX ISOTOPE REACTOR. Collins, W. C. (Y-12 Plant Union Carbide Corp., Oak Ridge, Tenn.); Scott, D. G.; Tackett, J. W.; Turner, P. W. Weld. J. (N. Y.), 46: 833-41(Oct. 1967).

Precision cylindrical, aluminum composite control plates for the HFIR were welded using the automatic gas tungsten-arc process. Aluminum filler metal ER 4043 and a vee-groove joint design were utilized. A commercial welding fixture was modified to minimize deflection of the mandrel and to provide additional positioning and holding devices. These features were necessary to assure precise dimensional control of the weldment. Results of tensile and bend tests of welded joints indicated that the composite cylinder would withstand very little deformation before failure occurred at the aluminum-core material interface. This zone tended to yield and fracture long before the weld became significantly stressed. Methods and equipment for dimensional analysis were developed to closely measure the effects of weld shrinkage, weld planishing, and explosive sizing on the diameter and shape of the control plate. The effectiveness of the welding fixture in removing heat from the weld zone was determined by comparing measured peak temperatures at the aluminum-core material interface with those based on idealized conditions. Weld planishing was found to be a convenient means of partially compensating for weld shrinkage and for adjusting undersized cylinders to specified dimensions. A weld finishing method was devised which indexed from the surface of the control plate and removed excess weld metal without removing adjacent material despite minor distortions along the reference surface. These methods are being used to fabricate control plates which have a 17.842 in. diameter and are 68$\frac{3}{8}$ in. long with a diametral tolerance of ±0.005 in. and a straightness tolerance of ±0.030 in. (auth)

2592 LOW TEMPERATURE BRAZING OF TZM. Nair, Frank B, Jr. (Climax Molybdenum Co., Ann Arbor, Mich.). Weld. J. (N. Y.), 46: 850-1(Oct. 1967).

A method is described for use in low temperature brazing of TZM tips to copper resistance-welded electrode shanks to form joints having increased electrical resistivity and decreased thermal conductivity. (F.S.)

2593 CrB-TYPE EQUIATOMIC COMPOUNDS OF EUROPIUM, YTTERBIUM, AND ALKALINE EARTH METALS WITH Si, Ge, Sn, Pb. Merlo, F.; Fornasini, M. L. (Univ. of Genoa). J. Less-Common Metals, 13: 603-10(Dec. 1967).

Intermetallic compounds of Eu and Yb with Si, Ge, Sn, and Pb were prepared together with the corresponding compounds of the alkaline earth elements. The crystal structures of YbSi, EuSi, BaSi, EuGe, SrGe, BaGe, EuSn, SrSn, BaSn, and SrPb were determined. These compounds crystallize with the CrB structure type and their lattice constants, atomic parameters, and interatomic distances are reported. (auth)

2594 MECHANICAL PACKING OF SPHERICAL PARTICLES. McGeary, R. K. pp 209-36 of Vibratory Compacting. Vol. 2. Perspectives in Powder Metallurgy, 1967.

An idealized experimental study of particle packing is reported. Spherical metal shot, steel, W and Al, of several discrete, narrow-size ranges is packed in glass containers by mechanical vibration. One-size, binary, ternary and quaternary packing arrangements and the dynamic process of packing are studied visually. One-size spheres pack in an orthorhombic arrangement with a density 62.5% of theoretical density. The effect of container on packing efficiency of one-size spheres is observed. Forming of high-density multicomponent packings requires at least a sevenfold difference between sphere sizes of individual components. A quaternary packing with a density 95.1% of theoretical density is formed from spheres with diameter ratios 1:7:38:316 and volume compositions 6.1:10.2:23.0:60.7%, respectively. Multicomponent packings are accomplished in number of steps equal to number of components. Ultimate density is independent of forming rate. Rate of packing is affected by frequency and acceleration of vibration, density of materials, fineness of components and evacuation of container. Pneumatic and electronic vibratory equipment are compared. (Rev. Met.Lit.)

2595 TUNGSTEN WIRE BOLSTERS POWDER. Iron Age, 199: No. 17, 77(Apr. 27, 1967).

A tungsten wire-reinforced Ni-base composite has been fabricated which has stress rupture life and tensile strength superior to that of the best known superalloys. The matrix alloy is Hastelloy X. Grade NF 10-mil tungsten wire is used as the reinforcement. For the hot pressing, a cylindrical graphite die with a rectangular cavity and graphite punches were used. A vacuum of

less than one micron was drawn before sintering. The die was inductively heated to 2150°F and a hydraulic pressure of 4000 to 4500 psi was applied. (Rev.Met.Lit.)

2596 PROPERTIES OF ANNULAR SEAM WELDED JOINTS IN THIN WALLED TUBES OF ZIRCONIUM ALLOY. Rybakov, Yu. V.; Podvol'skii, L. I. Weld. Prod. (USSR)(Engl. Transl.), 13: No. 10, 40-4(Oct. 1966).

Resistance butt welding of Zr-1% Nb alloy tubes with application of a roll welder and supporting mandrel is described. The welded tubes are vacuum annealed at 700°C and corrosion tested in a mixture of steam and argon at 340°C. Data are given on corrosion resistance, tensile strength, yield point, ductility and hardness of seams and dependence of these on welding current and heat treatment. (Rev. Met. Lit.)

2597 APPLICATION OF THE ZONE MELTING METHOD TO THE PURIFICATION OF ZIRCONIUM AND STUDY OF CERTAIN PROPERTIES OF THE METAL THUS PURIFIED. Langeron, J. P. Rev. Hautes Temp. Refract., No. 2, 137-56(Apr.-June 1965). (In French).

Extreme purification of Zr by vertical zone melting in static-ultra-vacuum provides information on influence of various metallic and nonmetallic impurities on recrystallization temperature and value of resistivity ratio (ratio of resistivities of a given specimen at boiling point of liquid H and at room temperature) of the recrystallized zone-melted product. Static-ultra-vacuum method isolates Zr bar from pumping equipment, thus preventing progressive contamination of metal by C from oils used in diffusion pumps. Mechanisms of purification noted are: segregation of Cd, Ag, Au, Ni, Fe and Cr; inverse segregation of Hg (as expected) and Cu (abnormal); anomaly in segregation of Hf; elimination of certain impurities by a distillation effect superimposed on segregation and most pronounced with respect to Cu, Ag, Fe, Mn, Cr and Al; apparent absence of this effect in case of certain extremely volatile impurities such as Zn and especially Cd, indicating that a coefficient of activity must be taken into account and not just the vapor tension ratio. Grain size and hardness of zone-melted material are shown. Mechanism of allotropic transformation and preparation of large crystals are discussed in connection with observation that the zone-melted bars are composed of very large alpha crystals elongated in the direction of the axis of the bar, some of them more than 3 cm long. Includes report of preliminary studies of zone melting of Zr in Ar atmosphere and in normal vacuum. (Rev. Met. Lit.)

2598 ALLOYING STEEL WITH TUNGSTEN IN THE LADLE USING BRIQUETS. Chirkov, N. A. Stal, No. 3, 219-20(Mar. 1967). (In Russian).

The mechanical properties (tensile strength, elongation, reduction in area, impact strength), hydrogen content and amount of nonmetallic inclusions in 5KhNV alloy steel containing 0.65% W are not affected by the W alloying method. Three alloying methods were tested: with concentrate (containing 60% WO_3) in the furnace during rimming; with tungstanate briquets in the ladle; and with solid ferrotungsten in the furnace. The cost of steel production, using the briquets, however, was less due to better assimilation of W from the briquets. The effect of the amount of reducers (Al or Si) on the thermal reduction reaction was investigated. The aluminothermal tungstanate briquets raise the temperature of the steel 18°C per 1% of W. The silicothermal tungstanate briquets have no cooling effect. (Rev. Met. Lit.)

2599 MACHINING "MOLY" DIECASTING DIES. Bydash, Fred A. Mod. Mach. Shop, 39: No. 12, 110-15 May 1967).

Mo dies and die components (die inserts, cores and ejector pins) are machined by several types of operations: turning, milling, grinding, drilling and tapping. Details of machining methods used to make the parts used in the production of ferrous diecast parts are described, including tool geometry, side rake angle, cutting speed, depth of cut and feed rate. (Rev. Met. Lit.)

2600 INFLUENCE OF THE CONDITIONS OF PRODUCTION OF HAFNIUM ON ITS MECHANICAL PROPERTIES AND CORROSION RESISTANCE. Armand, M.; Givord, J. P.; Salmon, M.; Tortil, P. Rev. Met. (Paris), 63: 415-21(May 1966). (In French).

Tensile properties, hardness, impact strength and forgeability of Hf are even more sensitive to the presence of oxygen than are these properties in Zr and the search for satisfactory ductility in the early stages of development requires refining of the sponge product by the expensive Van Arkel process. Improvements in the Kroll process for the manufacture of Hf sponge have made it possible to substitute slow melting in an electron beam furnace (electron bombardment melting) for the intensive purification technique represented by the Van Arkel process. It is possible to predict that refining can be entirely eliminated and ingots with a low enough oxygen content produced directly from sponge, i.e., by remelting sponge in an arc furnace. It appears that there should be about 300 ppM of Fe in Hf to guarantee satisfactory corrosion resistance in 400°C-steam. These conclusions are drawn from fragmentary studies of small samples of Hf and are not presented as definitive. (Rev.Met.Lit.)

2601 STAINLESS LININGS BY AUTOMATIC WELDING IN NUCLEAR CONSTRUCTIONS. Berniolles, J. Soudage Tech., Connexes, 20: 375-89(Sept.-Oct. 1966). (In French).

Interior linings of reactor vessels are discussed. Tanks which function at 300°C are made of Mn-Mo alloy steels with weld-deposited coatings of stainless steel. Solid flux submerged arc and gas flux welding are employed. Welding process arrangements are described: twin filler metal electrodes with opposite polarities in a series arc order; twin filler metal electrodes of the same negative polarity, with and without oscillation, and positive work polarity; strip wire electrodes; and strip welding and welding under a protective gas with twin filler metal electrodes, one of which is cooled. The problem of base metal dilution and the role of flux are considered. The effect of the wire polarity on energy and metal transfer, function of flux, amperes, current density, weld speed, and arc voltage are determined. Also considered are the influences of preheating of weld wire, base metal preheating, and angle of the welding electrode. (Rev.Met.Lit.)

2602 RECRYSTALLIZATION CHARACTERISTICS OF Al-0.3 WT PERCENT Zr ALLOYS. Nishikawa, Seiichi; Nagashima, Nobuo; Sawaguchi, Tetsuo Light Metals, 16: No. 6, 5-13 (Nov. 1966). (In Japanese).

Two kinds of Al-0.3 wt % Zr ingot were prepared, one of which was cast in permanent mold and the other in heat insulating brick mold. The recrystallization characteristics of the alloy sheets produced from the above ingots were studied under several heat treated conditions. Under the condition of practical operation, the best heat resisting properties would be given by so-called supercooled solid solution produced from homogeneous liquid phase by rapid solidification. However, rather excellent properties were given even by slow solidification when subjected to suitable heat treatments. The effects of heat treatments on heat resisting properties were divided into two temperature stages. In the recovery stage (at lower temperature), there was observed a kind of low-temperature temper hardening, which probably resulted from the so-called Cottrell pinning of dislocation by Zr atoms. However, the reason of the above hardening is still ambiguous and shall be re-examined in more detail. In addition, competition between recovery and recrystallization must be taken into account, because it may effect retardation on the following recrystallization kinetics. In recrystallization stage (at higher temperature), fine precipitates of Zr-rich phase appeared by prolonged aging at suitable temperatures. These precipitates appeared preferentially at dislocations introduced by cold working. The age hardening and locking mechanism of dislocations may be very effective in improving high-temperature properties of this alloy. In slowly solidified material, precipitation hardening was scarcely observed in as-cast state. However, when it was solution heat treated at high temperature, fairly strong age hardening was restored. The age hardening response of the alloy was usually very sluggish. Even being aged at 350°C, hardening began to take place at about 50 hr after the start, and the hardness attained the maximum value several hundred hours later. In practice, it may be required to accelerate the action by cold working. The increment of hardness by aging was about 10 VHN. (Rev. Met. Lit.)

2603 HEAT TREATMENT OF COPPER-BERYLLIUM ALLOYS. Kuhn, Joseph B. Rame, 4: 37-44(Mar. 1966). (In Italian).

Cu-Be alloys have good tensile strength, hardness, corrosion resistance, electric conductivity, and thermal conductivity in the heat-treated state. They are easily machined and plastically deformed and subjected to relatively low-temperature aging. These alloys can also be subjected to solution heat treatment and artificial aging to improve their tensile properties and workability. Their application can be extended to the electrical industry, electrodes, aerospace, bearings, valves, springs, bolts, electrical contacts and propellers. (Rev. Met. Lit.)

2604 FORMING PROJECTIONS ON TUBES. Monroe, Robert E.; Vagi, Julius J. (to U. S. Atomic Energy Commission). U. S. Patent 3,354,290. Nov. 21, 1967.

A method is described for forming an external projection on a zirconium-alloy tube by electrical heating and pressure. In this method the tube is internally supported on a water-cooled copper-alloy mandrel, a copper-alloy electrode with a concave cylindrical surface portion having a recess is pressed against the outside of the tube, and an alternating current of low voltage and high amperage is applied across the tube wall between the electrode

and the mandrel, whereby the external projection is formed, at the region of the tube engaged by the electrode, by thinning, flowing and thickening of the tube region. (P.G.C.)

2605 METHOD FOR EXTRUDING MOLYBDENUM AND TUNGSTEN. McDonald, Robert E.; Leitten, C. F. Jr. (to U. S. Atomic Energy Commission). U. S. Patent 3,350,907. Nov. 7, 1967.

A metal selected from molybdenum, tungsten alloys thereof is extruded utilizing a volatile oxide bearing surface formed by heating the metal 2850 to 3700°F and exposing the heated metal to an oxidizing atmosphere. (P.G.C.)

2606 BERYLLIUM FOIL FABRICATION. Cadden, Jerry L.; Friar, D. H. (to U. S. Atomic Energy Commission). U. S. Patent 3,354,538. Nov. 28, 1967.

A process for preparing beryllium foil having a nominal thickness of about 0.0025 of an inch is described. A quarter-inch-thick beryllium sheet is sealed in a mild steel envelope, rolled to the desired thickness at 600 to 800°C, and thereafter rapidly cooled to effect the release of the beryllium foil from the envelope material. (P.G.C.)

Properties Evaluations

Refer also to abstracts 2082, 2281, 2568, 2668, 3158, 3162, and 3201.

2607 (BNWL-547) MATERIALS CHARACTERIZATION STUDY. ULTRASONIC LONGITUDINAL AND SHEAR VELOCITIES OF CANDIDATE ISOTOPE ENCAPSULATION MATERIALS. Jolly, William D. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Oct. 1967. Contract AT(45-1)-1830. 14p. Dep. CFSTI.

Ultrasonic longitudinal and shear velocities were measured for Inconel X, Hastelloy X, Hastelloy C, TZM, 304L, 416, L605, Haynes 25, tungsten, tantalum, and molybdenum, which are candidate cladding materials for isotope heat capsules. The specimens used for this program were random samples of several configurations which required the use of different methods for velocity measurements. The differential path method was employed when possible because of its inherent accuracy. The pulse echo method and the through transmission method were required for some specimens, while for others the plate resonance method was used. Methods used for the velocity measurements are described briefly. Included is a table listing the composition of materials and the method of velocity measurement for each specimen. A table of velocity data for the materials considered is provided which lists velocity in cm/sec and in./sec, and calculated values of acoustic impedance in g/cm^2-sec. (auth)

2608 (COO-1247-7) ELECTRICAL AND DEFECT PROPERTIES OF THIN METALLIC WIRES. Progress Report No. 5. Bass, Jack; Blatt, Frank J. (Michigan State Univ., East Lansing). Sept. 1967. Contract AT(11-1)-1247. 6p. DTIE.

PLATINUM —electric conductivity of fine wires of, quenched in superfluid helium
ALUMINUM —properties of, size effect studies
WIRES —electrical and defect properties of thin metallic, research on (D.L.C.)

2609 (EURAEC-1892) STUDY OF EMBRITTLEMENT BY PLASTIC FATIGUE OF STEELS FOR REACTOR VESSELS. Final Report No. 1(Vol.2). Salkin, R. V.; Lagasse, P. E. (Centre National de Recherches Metallurgiques, Liege (Belgium)). July 5, 1967. Contract 005-63-12-TEEB. 128p. (EUR-3385). Dep. CFSTI.

Work performed under United States-Euratom Joint Research and Development Program.

Embrittlement of steel induced by alternate plastic deflections and the influence which periods of maintenance at maximum deformation have on plastic fatigue stresses were studied for three construction steels with high limits of elasticity. Symmetrical tensile compression with imposed deformation and biaxial alternate bending were applied. Fatigue bending tests and damage by plastic fatigue tests were performed at 20 and 300°C. (F.S.)

2610 (GEAP-5512) REACTOR PRIMARY COOLANT SYSTEM RUPTURE STUDY. Quarterly Progress Report No. 9, April-June 1967. (General Electric Co., San Jose, Calif. Atomic Power Equipment Dept.). Aug. 1967. Contract AT-(04-3)-189. 88p. Dep. CFSTI.

Topics discussed include: leakage and severance resulting from low-cycle fatigue and corrosion; the use of the computer code PAPA for stress analysis in the elastic-plastic regime; hydraulic pressure burst testing of flawed A-106B pipe; crack growth rates in Type 304 stainless steel; and effects of BWR environment on the fatigue of Type 304 stainless steel. (D.C.C.)

2611 (IS-1713) THE THERMAL DIFFUSIVITY OF GOLD. Shanks, H. R.; Burns, M. M.; Danielson, G. C. (Iowa State Univ. of Science and Technology, Ames). Oct. 27, 1967. 9p. (CONF-671110-2). Dep. CFSTI.

From 7th Conference on Thermal Conductivity, Gaithersburg, Md.

The thermal diffusivities of four gold samples were measured from 325 to 1225°K. The sample purities varied from about 95 to 99.999% and the resistivity ratios from 3 to 600. The thermal diffusivity of gold was found to be sensitive to the impurity concentration. The thermal diffusivity data were combined with published specific heat data to obtain thermal conductivity values. Electrical resistivity and Seebeck coefficient measurements were also made on the samples. (auth)

2612 (MLM-1402) REACTOR FUELS AND MATERIALS DEVELOPMENT PLUTONIUM RESEARCH: 1966 ANNUAL REPORT. (Mound Lab., Miamisburg, Ohio). Oct. 16, 1967. Contract AT(33-1)-Gen-53. 50p. Dep. CFSTI.

Phase equilibria in the composition range Pu-$PuFe_2$-$PuMn_2$ were investigated. A continuous series of solid solutions was formed between $PuFe_2$ and $PuMn_2$ with a minimum liquidus temperature occurring near the compound $PuMn_2$. A eutectic valley extended completely across the ternary phase diagram between the Pu-Fe binary eutectic and the Pu-Mn binary eutectic. A ternary eutectic located very close to the Pu-Fe binary composition had a temperature of 410°C. The effect of Zr additions on the phase equilibria of U-Pu alloys is being studied in the evaluation of potential fast breeder reactor fuels. The U-Zr and U-Pu binary systems were reviewed. The ternary alloys exhibit a continuous bcc solid solution in equilibrium with liquid. This solid solution decomposes at temperatures below 670° depending upon the composition. A four phase reaction occurs at 610°C. Internal friction of Pu, as measured with a low frequency inverted torsion pendulum, increased from 0.0007 in the α phase to 0.2 in the ϵ phase. The internal friction of a given allotrope appeared to be a function of the mechanism by which the phase was formed. From measurements of the internal friction and relative shear modulus during a phase change, the difference between a diffusional transformation and a shear transformation mechanism was determined. A temperature change caused a temporary increase in the internal friction of each allotrope of U and Pu. The rate at which this temporary increase decayed was correlated with self-diffusion. A simple, but sensitive, dilatometer was developed for the determination of solid state phase reactions. Expansion or contraction during each phase change was easily discernible on the dilation trace of a Pu specimen only 0.062 in. thick. The heat capacities of the allotropes of Pu, including the liquid phase, were measured at 60 to 731°C. A value of 8.50 ± 0.27 cal/g-atom-°C was determined for the heat capacity of the delta-prime phase at 468 to 475°C. Measurements of the latent heat of the $\gamma \rightleftharpoons \delta$ transformation indicated that by the method employed more heat was absorbed in the $\gamma \rightarrow \delta$ transformation, 165 cal/g-atom, than released in the $\delta \rightarrow \gamma$ transformation, 89 cal/g-atom. The measured liquid densities of two Pu-Ce alloys with 4.8 and 75 at. % Ce, respectively, agreed within ±0.6% with values calculated for ideal solutions of Pu and Ce. The liquid densities of four Pu-U alloys with 5.5, 10.8, 16.6 and 22.4 at. % U, respectively, were determined from near their liquidus temperatures to above 800°C. All of the solutions were approximately 1.5% more dense than calculated for ideal solutions; the derivation increased slightly with U concentration. The viscosity of liquid U decreased from 6.5 centipoise at the melting point, 1133°C, to 5.4 centipoise at 1248°C. The change in viscosity with temperature agreed well with predicted values. The measurements of Au and Pb over extended temperature ranges showed a linear relationship between the logarithm of viscosity and reciprocal temperature. The viscosities of five Pu-U alloys with 5.5, 10.8, 16.6, 22.4 and 28.5 at. % U were measured from near their liquidus temperatures to nearly 800°C. The initial dilution of Pu with U caused an abnormally large increase in the viscosity of Pu which reached a maximum of 10.3 centipoise at 621°C for the 10.8 at. % U alloy. The measured heat capacity of PuO_2 increased smoothly from 0.070 cal/g at 400°K to 0.082 cal/g at 1000°K. The data were approximately 10% higher than literature values for the heat capacity of UO_2 over a similar temperature range. (auth)

2613 (NAA-SR-Memo-12440) LITHIUM HYDRIDE-HEAVY METAL SHIELDING EXPERIMENTS. Thiele, A. W. (Atomics International, Canoga Park, Calif.). Apr. 25, 1967. 34p. Dep. CFSTI.

The attenuation of fission spectrum neutrons and gamma rays in slab shields composed of lithium hydride, uranium, and lead has been measured. The secondary gamma ray production and attenuation in the uranium and lead shields were determined. The neutron and gamma ray attenuation in laminated shields was also measured

A disc source and simple geometrical arrangements were used to minimize the uncertainty in the analytical interpretation. (auth)

2614 (TRG-Report-1550) FINAL REPORT ON THE CREEP PROPERTIES OF MOLYBDENUM AT 650 TO 750°C. Bowers, J. E.; Lushey, R. D. S.; Sansom, P. W. J. (British Non-Ferrous Metals Research Association, London (England)). Jan. 1967. 16p. Dep. CFSTI. UK 5s. 6d.

Pure molybdenum sheets, 0.04 in. thick, prepared from both arc cast ingot and sintered slab were creep tested at 650 and 750°C. For each material tests were done on both recrystallized strip and samples given a stress-relieving (recovery) anneal. Sheet made from sintered stock had a better creep resistance than that made from arc melted material. (auth)

2615 (UCRL-17810) EFFECT OF A STRAIN INDUCED TRANSFORMATION ON THE TOUGHNESS OF HIGH STRENGTH MATERIALS. Laporte, Christian Pierre (California Univ., Berkeley. Lawrence Radiation Lab.). Sept. 1967. Contract W-7405-eng-48. 50p. Dep. CFSTI.

Thesis.

The fracture toughness of steels which exhibit a good combination of strength and ductility is examined. The principal variables investigated by fracture testing single-edge-notched specimens were the amount of C in the steels and the temperature of previous deformation. The toughness was found most sensitive to rolling temperature at low testing temperatures, but keeps a constant value in the vicinity of M_D. Rolling performed at 450°C depressed the temperature M_D and, thus, the amount of martensite induced during straining. For this temperature the toughness has been found very low, especially for the lowest C-content alloy. Good values of toughness (100 to 130 ksi $\sqrt{\text{in}}$) found for alloys whose strength was varying from 130 ksi to 200 ksi should still accompany higher strength levels (250 ksi) with a steady ductility (25%). (auth)

2616 (ORNL-tr-1791) OCCURRENCE OF A DISTINCT YIELD POINT IN VANADIUM ALLOYS. Bohm, H.; Mir, F. Translated by R. Gregg Mansfield (Oak Ridge National Lab., Tenn.), from J. Less-Common Metals, 11: 408-16(1966). 10p. Dep. CFSTI. JCL $1.60 fs, $0.80 mf.

The effects of the Ti content, temperature, and strain rate on the appearance of a yield point in V alloys was studied. In binary V-Ti alloys a yield point is observed at a Ti content of more than a 5%. All ternary V-Ti-Nb alloys with 5-20% Ti and 20% Nb show yield point. The kinetics of strain aging can be described in terms of a mechanism proposed by Cottrell and Bilby. The activation energy for strain aging determined by a return-of-yield point method was found to be 23.7 kcal/mole in V-10Ti-20Nb and 21.7 kcal/mole in V-20Ti-20Nb, suggesting oxygen or carbon diffusion. The effects of titanium content on the yield point is discussed. It is shown that the disappearance of the yield point at 750 to 850°C and strain rates of 0.02-0.2/min can be explained on the assumption that the strain rate ϵ must exceed the value of $D \cdot \rho$ where D is the diffusion coefficient and ρ the dislocation density. (auth)

2617 DETERMINING THE LATENT HEAT OF FUSION OF ZIRCONIUM. Elyutin, V. P.; Maurakh, M. A.; Sverdlov, G. M. Izv. Vyssh. Ucheb. Zaved., Tsvet. Met., No. 2, 87-8(1967). (In Russian).

A 30% disparity exists in the values of the latent heat of fusion of Zr shown in published data. A direct experimental determination of the latent heat of fusion of Zr was made on a calorimetric installation which consists of an arc auto-crucible furnace with nonconsumable W electrode and a measuring chamber containing a fluid calorimeter. The calorimetric fluid is liquid Mg. The metal investigated was a Zr sponge (98.5% Zr) and a zirconium iodide. The metal was placed in a water-cooled Cu crucible with a graphite insert where it was melted. The melted Zr flowed through an opening in the bottom into the calorimeter. Accuracy of determination of the latent heat of fusion of Zr was found to be 5 ± 0.3 kcal/g/atm within 7% accuracy. (Rev. Met. Lit.)

2618 HEAT TREATABILITY AND PROPERTIES OF URANIUM ALLOYS. Tardif, H. P. Can. Mining Met. Bull., 68: 332-42(1965).

Density measurements, metallurgical studies, mechanical and corrosion tests and heat treatability evaluations were made on U-base alloys containing Mo, Ti, Zr, Cb, V, Cr, Mn, Si, Nb, Ni and other elements in various binary, ternary and quaternary combinations. Tables give data on the crystallographic characteristics of U, the behavior of various elements in U, the Rockwell C hardness of U alloys, compression and impact properties, effects of tempering temperature on the hardness of various alloys and tensile and bend properties. Results show that U alloys are heat treatable. Binary U-2%Mo alloys and several complex alloys have been produced with hardnesses up to Rockwell C 52-57. Very slight differences in chemistry and heat treatment may affect the strength and ductility considerably. The corrosion resistance of U appears to be increased by the addition of small amounts of Ni or Cr. 20 ref. (Rev. Met. Lit.)

2619 FRACTURE TOUGHNESS AND STRESS-CORROSION CRACKING OF SOME TITANIUM ALLOY WELDMENTS. Huber, R. W.; Goode, R. J.; Judy, R. W. Jr. (Naval Research Lab., Washington, D. C.). Weld. J. (N. Y.), 46: 439s-47s(Oct. 1967).

Fracture toughness and stress-corrosion cracking characteristics have been determined for a variety of 1 in. thick titanium alloy plates and welds. The drop-weight tear test (DWTT) and a bend-bar K_{Ic} test were used in the fracture toughness studies. A precracked cantilever bend specimen was used for the stress-corrosion cracking studies. The properties of as-deposited and heat-treated gas metal-arc, electron beam, and a few plasma arc welds are compared with those of as-received and heat-treated base metal plate of similar chemical composition. By comparing the DWTT and K_{Ic} results with a fracture toughness index diagram developed for 1 in. thick titanium alloy plate, predictions can be made of the amount of prefracture plastic strain required to cause the welds to fracture. The results of a study on the stress-corrosion cracking resistance of as deposited and heat-treated gas metal-arc welds and as-deposited electron beam welds in water containing 3.5% NaCl were also compared to those obtained for the base metal. The critical stress intensity parameter for stress-corrosion cracking to occur, K_{Iscc}, was determined for as-deposited and heat-treated gas metal-arc welds and as-deposited electron beam welds in water containing 3.5% NaCl. The results indicate that for many alloys considerable differences in resistance can be expected between the base metal and the weldment. For some of the alloys, improvements were made in the stress-corrosion cracking resistance and fracture toughness of the weldments with postweld heat treatments or in some cases by heat treating the base metal prior to welding. Application of post-welding heat treating procedures to a large structure may be difficult; therefore, the fracture toughness and stress-corrosion cracking resistance of the as-deposited weld are considered highly critical aspects in the failure-safe design and fabrication of large, welded structures. (auth)

2620 SPOTLIGHTED DOMESTIC REACTOR-USE STEELS. Hasegawa, Masayoshi (Waseda Univ., Tokyo). Genshiryoku Kogyo, 13: No. 5, 5-10(May 1967). (In Japanese).

The construction of power reactors and pressure vessels for light-water reactors in particular require high-grade thick steels. The iron and steel industry in Japan, has provided good quality steels for other industries. Research on reactor steels was started in 1963. It was shown that domestic steels were satisfactory, and A302B was even superior to foreign steels, for use in reactor pressure vessels. The research status on steels, and the results of studies in Japan are described on reactor pressure-vessel steels irradiation tests of steels, irradiation-test methods, irradiation brittleness of ASTM A302B steel, and factors affecting the irradiation brittleness. ASTM samples were used and compared with foreign steels considering difference in methods of steel manufacturing, the effects of steel thickness and welds, and effects of long periods of heating. (NSA of Japan)

2621 HYDROSTATIC PRESSING OF POWDERS. van Buren, Charles E.; Hirsch, Harold H. pp 27-64 of New Methods for the Consolidation of Metal Powders. Vol. 1. Perspectives in Powder Metallurgy, 1967.

Studies on Fe, W and ceramic-aluminum oxide powders have shown that hydrostatic pressing produces compacts with improved mechanical properties as compared to those produced by die pressing. These properties are dependent on pressure, particle hardness, size distribution and granulations. Results for as-pressed properties show that green density and strength increase with forming pressure and that the slope of the density versus forming pressure curve decreases with increasing particle hardness. The higher the density of the powder, the higher the green density for a given pressure. Fine powders produce stronger green compacts and generally show a more rapid increase in strength as the forming pressure is increased than coarse materials. De-airing has no significant effect on green properties. Granulation does not improve green density and, for very hard materials, appears to reduce green strength. The increase in sintered density with forming pressure becomes less pronounced as the hardness of the particles increases. Ductile powders show an increase in sintered strength with forming pressure. When powders become very coarse, strength drops off. Granulation has a negligible effect on sintered properties while the effects of de-airing vary with the type of powder. The greatest improvement in hydropressing as opposed to die pressing appears to be in the ductility of sintered bodies. Uniformity in density of pressed bodies is somewhat better for hydropressed material, producing more uniform shrinkage during sintering. Hydropressing can

consolidate powders that can be formed only with difficulty by die pressing. This is particularly true for very coarse powders and fine, hard powders. (Rev.Met.Lit.)

2622 THE TENSILE BEHAVIOR OF Pu–1 WT PERCENT Ga AT - 60, 30, AND 77°C. Beitscher, S. (Dow Chemical Co., Golden, Colo.). J. Nucl. Mater., 24: 113-17(1967).

The Pu/1 wt % Ga alloy specimens 5.7 cm long, 1.25 cm wide, and 0.18 cm thick were punched and tested for tensile behavior. The data were tabulated for specimens at −60, 30, and 77°C. Within the range of variables investigated, the alloy displayed ductile behavior and gradual changes of properties with temperature. The yield and tensile strengths decreased 30% as the temperature was increased from −60 to 77°C. Uniform elongation decreased 20% during testing. Increased strain rate had a small effect upon yield and tensile strengths. Plastic flow curves of the alloy up to the point of maximum load at the intermediate strain rate are given. (J.C.W.)

2623 THERMODYNAMIC BEHAVIOR OF NIOBIUM CARBIDE, CARBONITRIDE, NITRIDE, AND SULFIDE IN STEEL. Mori, T. Tetsu To Hagane, 51: 2031-3(1965).

The behavior of Nb in commercial steels, with special attention to the comparative tendencies of niobium carbide, carbonitride, nitride and sulfide to be formed is studied. Chemical compositions of samples are the Fe−Nb−C, Fe−Nb−N, Fe−Nb−C−N and Fe−Nb−C−S systems. Experimental procedure and results are discussed. The relationship between log of equilibrium concentration product and the N/N + C mole ratio or 1/T for each sample of the Fe−Nb−N system is given. Results of x-ray diffraction and chemical analyses of residues extracted from Fe−Nb−C−S alloys are listed. Steel compositions in which niobium carbide and niobium carbonitride are formed and the role of Mn are discussed. Conditions in which niobium nitride and niobium sulfide are formed are reported. (Rev.Met.Lit.)

2624 APPLICATION OF SOFT MAGNETIC MATERIALS IN NUCLEAR ENGINEERING. Knorr, W. Z. Angew. Phys., 21: 438-41(Nov. 1966). (In German).

Highly-homogeneous soft Fe materials with low contents of both alloying additives and accompanying (or satellite) elements are required in large-scale manufacturing of magnetic components used in nuclear engineering. In this category, magnetic yoke magnets are important subassemblies. Yokes are forged, laminated and cast and their preferred and alternate chemical compositions are detailed. The purity of Fe appears to be an important factor in yoke manufacturing. A special soft Fe of 0.04% maximum C, traces of Si, 0.12−20% Mn, 0.020% maximum P and 0.20% maximum S is recommended. This material has a high saturation factor, a steep induction curve and a narrow hysteresis loop with a coercive force of less than 1 oersted. There is no magnetic aging. Numerous casts were tested; a 70-ton ingot of vacuum cast steel was used for the forging of a magnetic pole. (Rev.Met.Lit.)

2625 ELECTRON MICROANALYSIS OF GALLIUM AND IRON IN PLUTONIUM–GALLIUM AND PLUTONIUM–IRON ALLOYS. Harvey, M. R.; Riefenberg, D. H. (Dow Chemical Co., Golden, Colo.). Contract AT(29-1)-1106. J. Nucl. Mater., 24: 104-6(1967).

Six alloys ranging from 0.56 to 2.12 wt. % gallium in the delta-stabilized region and four intermetallic compounds Pu_5Ga_3, $PuGa$, $PuGa_2$, $PuGa_3$ were prepared by induction and arc melting. The Ga specimens were homogenized and metallographically polished. Two Fe compounds, Pu_6Fe and $PuFe_2$ were arc melted, annealed, and polished. The samples were treated to avoid radioactive contamination. The samples were placed in a microprobe and an accelerating potential of 19 kV was used to eliminate interference from the second order $L\beta_1$ and $L\beta_3$ Pu lines. Intensities were averaged from counts on fifteen areas and converted to relative intensities by normalizing with a pure Ga standard. (J.C.W.)

2626 SOME CHARACTERISTICS OF NICKEL–THORIA ALLOYS PREPARED BY HOT PRESSING IN CARBON DIES. Ashall, D. W. (International Nickel Ltd., Birmingham, Eng.); Evans, P. E. Powder Met., 10: 326-43(Autumn 1967).

Fully dense nickel−thoria alloys, varying in ThO_2 content from 1.0 to 3.0 vol %, were prepared by a powder-metallurgical method. The structures of the as-pressed alloys were examined, and some of their mechanical properties measured. The effect on yielding behavior of the alloys of substituting MgO for ThO_2, and of varying the grain size of the matrix was also studied. An initial discontinuous yield was observed for as-pressed alloys, and a strain-ageing effect for both as-pressed alloys and worked material. Decarburization had no influence on the initial discontinuous yield, but removed the strain-ageing effect. The strain-ageing behavior of the alloys was investigated, and the interaction of carbon with dislocations demonstrated. (auth)

2627 PHYSICAL PROPERTIES. Miner, W. N.; Schonfeld, F. W. (Los Alamos Scientific Lab., N. Mex.). pp 31-57 of Plutonium Handbook. A Guide to the Technology. Vol. I. Wick, O. J. (ed.). New York, Gordon and Breach Science Publishers, 1967.

Information made available since 1943 concerning the physical properties of Pu and its alloys is summarized. The crystal structure and temperature ranges of the allotropic forms are discussed. (B.L.M.)

2628 MACHINING TESTS WITH SINTERED MOLYBDENUM USING TURNING AND DRILLING OPERATIONS. Usbeck, P. Fertigungstech. Betr., 16: 228-30(1966). (In German).

Machining tests are carried out for turning and drilling operations under 5 mm dia with the purpose of increasing operating efficiencies. These tests are carried out with different hard metal tools and such cutting materials as X 79 WCo 18.5 and X 82 WMo 6.5 alloys. The tests are carried out with sintered Mo for 190 to 220 Vickers hardness and 42.8 to 55.5 kp/mm^2 tensile strength. Fracture phases of the Mo material show crystalline to coarse-crystalline microstructures. The cutting tests are performed at various cutting rates and for different cutting periods. Both turning tests and drilling operations are employed. The results are given in terms of radial and edge wear as a function of cutting rate, cutting time and drilling path. A series of lubricants are used and the effects of lubricants are also investigated. (Rev. Met. Lit.)

2629 HEATING AND METALLOGRAPHY OF ULTRAFINE RECRYSTALLIZED TUNGSTEN WIRE. Davidson, Harold I.; Veleker, Thomas J. Wire Wire Prod., 41: 1628-30; 1709-10 (Oct. 1966).

Laboratory test methods were developed to evaluate ultrafine W wire structures resistance heated to the temperature necessary for the wire specimen to obtain the most advanced state of recrystallization its characteristics permit. This is to simulate maximum temperature conditions similar to those encountered by the ultrafine wire filaments of incandescent lamps in field operations. The procedure used is based on heating of the wire specimen by its own resistance, in hydrogen or vacuum, to 80% of its fusion amperage (about 2700°C). The wires are then mounted and examined metallographically. The elongated or interlocking-type structure and grain boundaries indicative of good, nonsag W wire are illustrated. A second structure type permitting slip or cleavage, a duplex structure and a structure where all the grains are equiaxed are also illustrated. Slip planes occasionally occur throughout the grains or crystal. These planes are formed as the wire diameter is reduced by the die. They can be seen if the polished specimens are deformed by twisting in the mount. (Rev. Met. Lit.)

2630 EFFECT OF GAS CONTENT ON TENDENCY TO DELAYED FRACTURE AND COLD CRACKING IN WELDING TITANIUM ALLOYS OF THE Ti–Al–Zr SYSTEM. Meshcheryakov, V. N.; Shorshorov, M. Kh.; Florinskii, Yu. B. Srar. Proizv., No. 11, 11-12(Nov. 1966). (In Russian).

The effect of oxygen content (0.13 and 0.14 to 0.45%) and hydrogen content (0.002 to 0.015%) on delayed fracture of Ti alloys of the Ti−Al−Zr system was investigated. Specimens of base metal were tested as well as argon arc welded specimens. Susceptibility to delayed fracture was determined according to minimum fracturing stress, shortest time to fracture, and amount of plastic deformation before beginning of fracture as determined by relative reduction of specimen in the notched section. Creep rate in an alloy containing 0.13−0.14% O is 2−3 times higher than in an alloy containing 0.45% O. An increase in oxygen content from 0.13−0.14 to 0.45% at a hydrogen content of 0.002% increases the minimum fracturing stress. The capacity for plastic straining and stress relaxation remains high, both in base and weld affected metal. Increasing the hydrogen from 0.002 to 0.015% considerably lowers the fracturing stress. (Rev. Met. Lit.)

2631 VACUMET HyMu 800. Alloy Dig., Ni-123, 2p.(Apr. 1967).

Physical constants, flux density, permeability, saturation induction, coercivity, tensile properties, and corrosion resistance are given for a vacuum-melted Ni−Mo−Fe alloy recommended as strip for laminations or torroids with a minimum permeability of 65,000 at 45 Gauss in strip of 0.010 to 0.001 in. thickness. The alloy is designed to produce higher permeability, particularly at low induction, for precise electronic and magnetic systems. Composition in %: 0.01 C, 0.50 Mn, 0.15 Si, 80 Ni, 5 Mo, remainder Fe. (Rev. Met. Lit.)

2632 MECHANICAL PROPERTIES. Gardner, H. R. (Battelle-Northwest, Richland, Wash.). pp 59-100 of Plutonium Handbook. A Guide to the Technology. Vol. I. Wick, O. J. (ed.). New York, Gordon and Breach Science Publishers, 1967.

The mechanical property data gathered on Pu and some of its

alloys from 1957 to 1964 are summarized. The data are mostly concerned with work done on Pu containing 250 to 1250 ppM total impurities. The mechanical properties of unalloyed Pu, β-stabilized Pu, Δ-stabilized Pu, Pu-rich alloys, and low-Pu alloys are presented in both tabular and graphical form. Phase diagrams for some systems are presented and 61 references are cited. (B.L.M.)

2633 SOLID STATE REACTIONS. Nelson, R. D. (Battelle-Northwest, Richland, Wash.). pp 101-43 of Plutonium Handbook. A Guide to the Technology. Vol. I. Wick, O. J. (ed.). New York, Gordon and Breach Science Publishers, 1967.

Solid-state reactions in unalloyed Pu and in some of the common alloys were examined. Transformation kinetics and heat-treatment parameters are discussed and related to microstructure, retained phases, and microcracking. (B.L.M.)

2634 LABORATORY TECHNIQUES. Nelson, R. D. (Battelle-Northwest, Richland, Wash.); Land, C. C.; Ellinger, F. H. pp 311-26 of Plutonium Handbook. A Guide to the Technology. Vol. I. Wick, O. J. (ed.). New York, Gordon and Breach Science Publishers, 1967.

The application of established laboratory techniques to Pu metallurgy is discussed. Modifications of major techniques necessitated by certain characteristics of Pu are reviewed. Detailed descriptions of thermal analyses, filtration for liquidus determination, dilatometry, x-ray diffraction, and density determination are given. (auth)

2635 ON THE TEMPERING BEHAVIOR OF 3Cr–W, 3Cr–W–Co, AND 12Cr–W–Co-TYPE TOOL STEELS FOR HOT WORK. Nishimura, Tomitaka. Tetsu To Hagane, 53: 28-42(Feb. 1967). (In Japanese).

The changes of hardness, Charpy impact value, lattice parameter of ferrite, internal stress in matrix, carbide reaction, elements in carbide and electron microstructure occurring during isothermal tempering of hot work tool steels of 3Cr–5W–0.3V (DSS), 3Cr–9W–0.3V/(DSH), 3Cr–5W–0.3V–3Co(CoSS), 3Cr–9W–0.3V–3Co(CoSH), 12Cr–7W–0.5V–5Co(DSE) and 12Cr–7W–0.5V–10Co(DSF) types for up to 1000 hr from 400 to 700°C have been studied. The results obtained were plotted against the tempering parameter and discussed in detail. Peaks of secondary hardening appear for 3Cr–W–(Co)-type and for 12Cr–W–Co-type. Charpy impact values show a broad valley near the parameter of peak hardness for 3Cr-type, and show a higher parameter than that of peak hardness for 12 Cr-type. Lattice parameters of matrix in DSS and DSE decrease with increasing parameters, and a maximum internal stress of about 100 kg/mm^2 is obtained for DSS and DSE. On the above isothermal tempering, the following sequence of changes in the carbides takes place in each type: $Fe_3C \rightarrow Fe_3C + W_2C \rightarrow W_2C \rightarrow W_2C + M_6C \rightarrow M_6C$ for 3Cr–5W–(Co)-type, $Fe_3C \rightarrow$ resolution $W_2C \rightarrow W_2C \rightarrow M_6C \rightarrow M_6C$ for 3Cr–9W–(Co)-type and $Fe_3C \rightarrow$ resolution $\rightarrow M_7C_3 \rightarrow M_7C_3 + M_{23}C_6 + M_7C_3 + Fe_2W \rightarrow Fe_2W + M_{23}C_6$ for 12Cr–W–Co type. Co decreases the rate of growth of carbide and the increase of resistance to softening during tempering is attributed to this effect. (Rev. Met. Lit.)

2636 STUDY OF THE WORKS OF CARBURIZATION AND DECARBURIZATION OF TUNGSTEN RIBBONS BY THE MEASURE OF THEIR CONDUCTIVITY. Wach, J.; Le Goff, P. Rev. Int. Hautes Temp. Refract., 3: 166-8(1966). (In French).

A tungsten ribbon heated to 1400 to 2100°K is placed in a bulb through which pentane vapor of very low pressure and high speed is circulated. The decomposition of the pentane gives hydrogen and carbon quantitively, which diffuses toward the interior of the metal. The speed of the reaction is measured by the quantity of hydrogen formed. The resistance of the ribbon is measured continuously. Indication is given of the ease of showing the relative importance of each of the three phases present: the state of the tungsten, the intermediate layer of CW_2, and the exterior layer of CW. (Rev.Met.Lit.)

2637 EFFECT OF ALLOYING WITH MOLYBDENUM, TUNGSTEN, AND OTHER ELEMENTS ON PROPERTIES AND STRUCTURE OF HEAT-RESISTANT NICKEL ALLOYS IN CAST STATE. Tsvetkova, V. K.; Khatalakh, R. F. Stal, No. 8, 738-41(Aug. 1966). (In Russian).

Seven dispersion-hardening, complex-alloyed, heat resistant Ni-base alloys of the KhN66VMTYu type were studied to determine the effect of W, Mo, and Fe (in place of Ni) on their mechanical properties (impact strength, tensile strength, yield strength, elongation, reduction in area), liquidus-solidus temperature, crystallization point, and internal transverse cracking of the cast ingot. The relations of mean coefficient of linear thermal expansion to temperature and of quenching temperature to hardness were also determined. An increase in ingot weight from 210–500 kg resulted in a lowering of the level of impact strength and mechanical properties of the cast structure at temperatures of hot plastic deformation. (Rev. Met. Lit.)

2638 THE EFFECT OF SMALL ADDITIONS AND IMPURITIES ON THE CRYSTALLINE LATTICE CONSTANT AND HEAT EXPANSION OF MOLYBDENUM. Ageev, N. V.; Model', M. S. pp 93-8 of Svoistva i Primenenie Zharoprochnykh Splavov. Moscow, Nauka, 1966. (In Russian).

The lattice constant of a Mo powder composite was measured by x rays using the method of back reflection from flat specimens (compact and powdered); constant a varied during etching the work hardened layer and during annealing the specimen. Annealing at 1200°C completely relieved stresses. The powders were annealed to remove work hardening caused by grinding in dual sealed quartz ampoules evacuated to a pressure of 1×10^{-4} mm Hg with a getter, for which titanium iodide shavings were used. The results of measuring the lattice constant a of specimens of varying purity, melted without deoxidizing additives, are tabulated; the table shows a marked reduction of a with purity. Interstitials were removed from the solid solution in the purer specimens of Mo purified by zone melting and electron beam melting. Lattice constant values were measured for alloys of Mo with reducing agents C, Ti, and Zr, and were greater for molten alloys not heat treated than for nonalloyed Mo, which points to a considerable impurity content in the solid solution. Thermal expansion of Mo of variable purity was measured. (Rev. Met. Lit.)

2639 THE DEFORMATION CHARACTERISTICS OF Nb, Ta, Mo, AND W. Buhler, H.; Wagener, H. W. Baender, Blech, Rohre, 7: 648-58(Sept. 1966). (In German).

An experimental press (plastometer) is used to investigate the deformation strength and the logarithmic limiting deformation ratio of Nb, Ta, Mo, and W with particular emphasis on the rate of deformation and the working temperature. The results serve to determine the so-called work hardening, rate and temperature coefficients which may be used in the calculation of the power and work requirements in the deformation of the metals. The flow curves of fcc metals may be divided into three ranges with three different work hardening coefficients. The work hardening coefficient is a measure of the formability of these metals. In Nb, Ta, and W there is no recrystallization at deformation rates of 0.25-125/sec at temperatures of 20 to 1400 or 1600°C. In Mo, recrystallization begins at 1400°C and a deformation ratio of 0.2. Following a curving decline of strength properties of lower temperatures, a straight-line decrease is observed at higher temperatures, which may be described by the temperature coefficient. The numerical values of the work hardening, rate and temperature coefficients of the four metals are of approximately equal magnitude and they follow similar rules. (Rev. Met. Lit.)

2640 SOME OBSERVATIONS ON NIOBIUM IN STEEL. Bell, D. R.; Contractor, G. P. Iron Steel (London), 39: 572-8 (Dec. 1966).

The effects of Nb on silicon-killed, low-carbon steel were investigated. In the as-rolled condition, it was found that small additions of Nb increased the yield strength and raised the transition temperature markedly, but that larger additions were less effective. In the normalized condition, the effects on yield strength were similar to those in the as-rolled condtion but the changes were less marked. The transition temperature was improved with all levels of Nb, the smallest addition (up to 0.04%) being most effective. Yield strength and transition temperature results obtained on commercial material qualitatively corroborated the findings of the laboratory steels. Nb was most effective in increasing the yield strength in ¼ in. plate, the effectiveness decreasing as the plate thickness increased. Rotating beam fatigue tests showed that Nb slightly increased the fatigue limit of smooth bars and had no effect on the fatigue limit of notched bars. The fatigue ratio was unaffected by Nb for smooth bars and decreased somewhat for notched bars. Limited data, based on electrolytically extracted residues, indicated that the major bulk of the Nb added to the steels was partitioned to the carbide phase. Similarly, much of the N present in the steels was found to occur in the residues. (Rev. Met. Lit.)

2641 INVESTIGATION OF THE EFFECT OF COMPLEX ALLOYING ON THE PHYSICAL AND MECHANICAL PROPERTIES OF NIOBIUM. Malashenko, I. S.; Movchan, B. A. pp 18-27 of Termoprochnost' Materialov i Konstruktsiya Elementov. Kiev, Nauk Dumka, 1965. (In Russian).

The alloys were prepared by electron-beam melting and their technological properties were assessed by cold upsetting cylindrical specimens 15 mm in dia and height. The presence of Mo increases their embrittlement considerably. The ternary and quaternary alloys, in which the ratio at. % Mo/at. % W > 1, are equivalent to alloys with at. % Mo/at. % W = 1 as regards strength at 293°K. However, they are inferior to these alloys as regards plas-

ticity. The microhardness of Nb sharply increases with an increase in the W content, reaching 355 dan/mm² at 20 at. % W. With a larger content of W the material in any condition is technologically inferior. In four- and five-component alloys, the strengthening of niobium with W, Mo, Zr, and V, preserving a satisfactory plasticity, reaches saturation at a total 12–15 wt % content of all alloying elements. The at. % Zr : at. % C ratio which determines the precipitation hardening of the alloys due to carbides is of paramount importance for the high-temperature strength. When Mo, W, and V are the alloying elements, the relation between strengthening and the change in the crystal lattice parameter of Nb is almost linear. (Rev.Met.Lit.)

2642 EFFECT OF CARBURIZATION ON THE SHORT-TIME STRENGTH OF TUNGSTEN, MOLYBDENUM, AND TANTALUM AT HIGH TEMPERATURES. Gorodetskii, S. S.; Rudenko, V. N. pp 14-17 of Termoprochnost' Materialov i Konstruktsiya Elementov. Kiev, Nauk Dumka, 1965. (In Russian).

The mechanical properties of W, Mo, and Ta were compared by heating specimens with graphite and W heaters in a neutral medium. Two methods were used for the investigation: the Vickers surface hardness was determined at room temperature after heating the specimen to a given temperature and holding; and the strength and plasticity of the studied metals was determined from 293 to 2690°K. The temperature was measured with OPPIR-019 or OPPIR-017 optical pyrometers and the breaking load was measured with a DS-0.2 model dynamometer. The residual elongation was determined in a MIR-12 microscope from graduation lines made on the specimen. The use of graphite heaters for investigating the mechanical properties of refractory sheet metals at high temperatures leads to a decrease in strength and an increase in plasticity. Their use is recommended only for short-time tests of not very chemically active materials. (Rev.Met.Lit.)

2643 A STUDY OF THE FREE ENERGIES OF FORMATION OF URANIUM MONOCARBIDE AND URANIUM DICARBIDE. Craig, James Arthur. Ann Arbor, Univ. of Michigan, 1966. 132p.
Thesis.

The free energies of UC_2 and UC were determined by measuring the activities of uranium in the two-phase regions UC_2 + C and UC + UC_2 of the uranium-carbon system at temperatures 1015 to 1165°K. Each activity was determined by measuring the concentration of uranium in a bismuth melt at equilibrium with the two-phase mixture of interest, UC_2 + C or UC + UC_2. From the concentration data, the activity of uranium in the melt can be obtained using activity coefficient data. The activities of uranium in the two regions are summarized. From the activity of uranium in the UC_2 + C region, the free energy of formation of UC_2 was computed. The free energy of formation of UC was computed and the calculated values are tabulated. (J.C.W.)

2644 THE EFFECT OF CARBON ON THE STRENGTH OF THORIUM. Skaggs, Robert Lee. Ames, Iowa, Iowa State Univ. of Science and Tech., 1967. 95p.
Thesis.

The flow stress of thorium carbon alloys containing from 0.008 to 2.83 atom percent carbon was measured at 4.2 to 573°K. Constant strain rate and constant stress measurements of flow stress were made at rates of deformation from 4×10^{-12} to 1.3×10^{-2} per second. The flow stress was found to be composed of a thermally activated component and an athermal component. The thermally activated component increases linearly with carbon content and with the logarithm of the strain rate. The athermal component is a function of carbon content and of strain. It was, in general, much smaller than the thermally activated component. The strengthening of thorium was due to a strong interaction between randomly distributed carbon atoms and moving dislocations. A yield point was observed which was a maximum at 250°K and decreased at both higher and lower temperatures. The size of the yield point increased with decreasing grain size, slow cooling from recrystallization temperature, and increasing carbon content. (Disser. Abst.)

Structure and Phase Studies

Refer also to abstracts 2318 and 2593.

2645 (IS-1696) A FORTRAN PROGRAM FOR THE CALCULATION OF DISLOCATION IMAGE PROFILES ACCORDING TO THE DYNAMICAL THEORY OF ELECTRON DIFFRACTION. Leamy, H. J.; Trivedi, R. (Ames Lab., Iowa). Oct. 1967. Contract W-7405-eng-82. 18p. Dep. CFSTI.

A FORTRAN program for calculation of the intensity distributions produced by dislocation arrays as observed by transmission electron microscopy under either bright or dark field conditions is presented. The programmed calculations are based upon the dynamical theory of electron diffraction in the two beam approximation. (auth)

2646 (UCRL-17872) MICROSTRUCTURE AND PLANE STRAIN FRACTURE TOUGHNESS OF HIGH STRENGTH ALUMINUM ALLOYS. Guest, Peter John (California Univ., Berkeley. Lawrence Radiation Lab.). Oct. 1967. Contract W-7405-eng-48. 57p. Dep. CFSTI.
Thesis.

The plane-strain fracture toughness of precipitation hardening high strength 7075-aluminum alloy has been determined in the fully precipitation hardened condition (38 ksi-$\sqrt{\text{in}}$) and compared with the overaged and underaged conditions at predetermined stress levels less than the yield strength. Plane-strain fracture toughness values were determined using the "pop-in" technique employing single edge notched large and small type specimens. The results show that the plane-strain fracture toughness was markedly improved for both underaged (61 ksi-$\sqrt{\text{in}}$) and overaged conditions (47 ksi-$\sqrt{\text{in}}$) accompanied by a corresponding minimal loss in yield strength. The underaged condition exhibited higher toughness than the overaged condition at equivalent yield strength levels. The work required to cause crack propagation was found to increase considerably for underaging and overaging, with a larger increase for the underaged condition, over the fully precipitation-hardened condition. The plane-strain fracture toughness was found to increase with increasing strain hardening exponent. (auth)

2647 STRUCTURAL DATA OF SOME RARE EARTH ALLOYS. Raman, A. (Louisiana State Univ., Baton Rouge). Naturwissenschaften, 54: 560-1(Nov. 1967).

Crystal structures were determined for the following alloy phases: Gd_2NiCu, Er_2AlSi, Er_4Ni_2Si, Er_2NiCu, Gd_4AlSi_3, Er_4AlSi_3, La_2FeSi_3, La_2NiSi_3, La_2CuSi_3, Ce_2NiSi_3, Ce_2CuSi_3, Ce_2Cu_2Si, Nd_2Cu_2Si, Gd_2Cu_2Si, Y_2Cu_2Si, Er_2Cu_2Si, Er_2CuSi_3, Nd_3Si_5, and Sm_3Si_5. (M.C.G.)

2648 THE EFFECTS OF ATOMIC ORDERING IN SOLID TERNARY ALLOYS BASED ON Ni_3Fe AND ALLOYED WITH VI-GROUP ELEMENTS: Cr, Mo, AND W. Eganyan, I. L.; Selisskii, J. P. (Central Scientific-Research Inst. of Non-Ferrous Metals, Moscow). Dokl. Akad. Nauk SSSR, 173: 325-8(Mar. 11, 1967). (In Russian).

The temperature dependence of Young's modulus and ordered kinetics of the Ni–Fe–Cr, Ni–Fe–Mo, and Ni–Fe–W alloys with the composition cross section of Ni_3Fe–Ni_3Cr, Ni_3Fe–Ni_3Mo, and Ni_3Fe–Ni_3W was investigated. Studies were confined to six alloys of Ni_3(Cr, Fe) with 0 to 12.5 at. % Cr, sixteen alloys of Ni_3(Fe, Mo) with 0 to 7.8 at. % Mo, and seven alloys of Ni_3(Fe, W) with 0 to 5.1 at. % W. (R.V.J.)

2649 THE CRYSTAL STRUCTURE OF RARE-EARTH GALLIDES (RE_5Ga_3). Palenzona, A.; Franceschi, E. (Univ., Genoa). J. Less-Common Metals, 14: 47-53(1968).

The crystal structures of phases with the composition RE_5Ga_3 have been examined for all rare earth (RE) metals by micrographical and x-ray powder methods. The RE_5Ga_3 phases of La, Nd, Sm, Gd, Tb, Dy have been found to crystallize with the Cr_5B_3 structure type, while the corresponding phases formed by Ho, Er, Tm and Lu belong to the Mn_5Si_3 structure type. For Ce, Pr, Eu and Yb no phase with this composition could be obtained. (auth)

2650 CRYSTAL CHEMISTRY OF THE ELEMENTAL RARE EARTHS AND THEIR TRIALUMINIDES. Pearson, W. B. (National Research Council of Canada, Ottawa). J. Less-Common Metals, 13: 626-8(Dec. 1967).

The layer stacking sequence in the structure of the rare earth elements and rare earth trialuminides is discussed. In terms of the relative size of the rare earth atoms and the 4f shells, the layer stacking sequence in the structures is identical. Instead of taking the ratios of the rare earth radius to the radius of its 4f shell their differences were used, and because the atomic parameters in the structures of the trialuminide phases are not refined the atomic volumes rather than interatomic distances were used. (auth)

2651 PRESSURE-TEMPERATURE PHASE DIAGRAM OF URANIUM METAL. Asami, Naoto; Yamada, Masao; Takahashi, Schuichiro. Nippon Kinzoku Gakkaishi, 31: 389-94(Apr. 1967). (In Japanese).

The electrical resistance changes of U during the transformations between the alpha (orthorhombic), beta (tetragonal), gamma (bcc) and liquid phases have been studied quantitatively up to 80 kg, 1200°C in cooling and heating at rates of 2 to 4°C/sec by utilizing a modified girdle-type apparatus. The samples were monitored by thermocouples and potential probes. The triple point was placed at 29.8 ± 1.2 kb, 798 ± 5°C. The hysteresis intervals at the heating and cooling runs for alpha-beta, beta-gamma and alpha-gamma transformations under high pressures were about 33, 21 and 17°C,

respectively, and these values were nearly the same as the hysteresis expected at zero pressure. The initial slope of (alpha, beta) and (beta, gamma) phase boundaries agreed well with the calculated temperature vs pressure curve based on the zero pressure thermodynamic consideration. The volume change was calculated as 0.49 cm^3/mole from the initial slope of gamma liquid phase boundary. (Rev. Met. Lit.)

2652 CONTRIBUTION ON STUDIES OF THE PLUTONIUM–THORIUM SYSTEM. Portnoff, A. Y.; Calais, D. (Centre d' Etudes Nucleaires, Fontenay-aux-Roses, France). J. Nucl. Mater., 24: 158-63(1967). (In French).

The plutonium–thorium phase diagram was studied by metallography, dilatometry, thermal analysis and x rays. The following transformations were established: a peritectic transformation at 596°C ± 6°C, liquid (Th, Pu) + β (Th, Pu) $\rightleftharpoons \zeta$, where ζ is a compound of well-defined composition Pu_7Th_3, as determined by microanalysis (the density is 15.5 g/cm^3, which is inconsistent with the formulas and densities quoted by Poole ($Pu_{13}Th_8$, d = 14 g/cm^3) and by Bochvar ($Pu_{16}Th_8$, d = 14.5 g/cm^3); and a eutectoid transformation at 582°C ± 5°C, β (Th, Pu) $\rightleftharpoons \alpha$ (Th, Pu) + ζ at a plutonium content of 49 ± 3 at. %, which is in contradiction with Poole's results but in rough agreement with Bochvar, who quotes 35 at % Pu at 600°C. (auth)

2653 EFFECTS OF THERMAL CYCLING ON URANIUM CARBON ALLOYS. Cappelaere, M.; Accary, A. Bull. Soc. Franc. Ceram., No. 72, 83-7(July-Sept. 1966).

Samples of U–C alloys, obtained by electron bombardment fusion, of varying compositions were used in the experiments. Temperatures ranged from 1000 to 2000°C, and were controlled by an optical pyrometer. Alloys richer in C than UC are characterized by a grain growth accompanied by an important fissuration. The mechanism of the phenomenon is an exaggerated growth accompanied by an oriented recrystallization. The number of cycles necessary to attain a particular grain shape is independent of the shape of the testpiece. About 200 cycles are necessary to attain a single crystal from a cylinder-shaped testpiece. (Rev. Met. Lit.)

2654 TRANSFORMATIONS IN PHASES MADE UP OF NiAs (Ni_2In) STRUCTURE TYPES. Brand, P. Z. Anorg. Allg. Chem., 353: 270-80(Sept. 1967). (In German).

In the intermetallic phases of the compositions $Ni_{1.8}Sn$, $Ni_{1.8}In$, and $Ni_{1.75}Ge$ the disorder–order transition was studied by x-ray methods and measurements of resistance in relation to temperature. The structure of the low-temperature modification of $Ni_{1.8}Sn$ could be determined in detail. In the quasibinary system NiAs–$Ni_{1.8}Sn$ additions of 10 mol % NiAs to $Ni_{1.8}Sn$ block the ordering process. (auth)

2655 ALLOYING BEHAVIOR OF PLUTONIUM. Ellinger, F. H.; Land, C. C.; Gschneidner, K. A. Jr. (Los Alamos Scientific Lab., N. Mex.). pp 191-247 of Plutonium Handbook. A Guide to the Technology. Vol. I. Wick, O. J. (ed.). New York, Gordon and Breach Science Publishers, 1967.

Practical aspects of plutonium alloys are considered. The information is arranged according to four types of alloy systems. Constitutional and crystal structure information on binary and ternary alloys is included. Plutonium alloy theory is discussed. (auth)

2656 METALLOGRAPHY. Johnson, K. A. (Nuclear Materials and Equipment Corp., Apollo, Pa.). pp 299-310 of Plutonium Handbook. A Guide to the Technology. Vol. I. Wick, O. J. (ed.). New York, Gordon and Breach Science Publishers, 1967.

The techniques of mounting, grinding, polishing, and etching Pu samples for metallography are discussed. The techniques of electron miscroscopic examination of the samples are discussed, and typical electron photomicrographs are reproduced. Illustrations of some representative microstructures of Pu alloys are also included. (B.L.M.)

2657 WORK-HARDENING CHARACTERISTICS OF POLYCRYSTALLINE α-URANIUM IN THE TEMPERATURE RANGE 20 TO 640°C. Jean-Louis, F.; Daniel, J. S.; Lacombe, P. (Ecole des Mines, Paris). J. Inst. Metals, 95: 314-15(Oct. 1967).

Tensile tests were conducted under a vacuum at strain rates of 0.33, 6.6, and 66%/min. The uranium contained 500 ppM impurities and was of two grain sizes: d = 20 and 130 μm. The results were analyzed in terms of the equation $\sigma = \sigma_0 + A\epsilon^m$, where σ and ϵ are the stress and strain, σ_0 is the yield stress, A is a constrant, and m a coefficient sometimes called the work-hardening coefficient. Behavior was found to be described by two expressions of the same form. The change took place at a transition strain of 0.03 at room temperature, decreasing to 0 at 400°C. Explanations of the behavior in terms of polygonization, and of a change in the principal mode of deformation, are discussed. (auth) (UK)

2658 EQUILIBRIUM DIAGRAM OF THE IRON–MOLYBDENUM SYSTEM. Sinha, A. K.; Buckley, R. A.; Hume-Rothery, W. J. Iron Steel Inst. (London), 205: 191-5(Feb. 1967).

The equilibrium diagram of the Fe–Mo system has been determined in the range 0–45 at. % Mo, by a combination of microscopic, x-ray, and dilatometric methods. The gamma loop has been established dilatometrically and extends to about 1.8 at. % Mo. A lambda or Laves phase Fe_2Mo with the $MgZn_2$ type of structure has been established and is formed very slowly by a peritectoid reaction at 950°C. A new R phase containing about 37.4 at. % Mo is formed peritectically at 1488°C and is stable only at high temperatures. It decomposes eutectoidally at 1245°C, and has the same kind of crystal structure as the R phase in the ternary Co–Cr–Mo system. At higher Mo contents, the existence of a mu phase at 39–40 at. % Mo is confirmed; its crystal structure is of the $D8_5$ type like Fe_7W_6 but with a lower percentage of Mo. The existence of a sigma phase near the equiatomic region is confirmed. The structural characteristics of the different phases are discussed. (Rev. Met. Lit.)

2659 INVESTIGATION OF THE $TiCr_2$–$ZrCr_2$ SYSTEM. Budberg, P. B.; Shakhova, K. I.; Alisova, S. P. pp 37-42 of Novye Issledovaniya Titanovykh Splavov. Moscow, Nauka, 1965. (In Russian).

High-temperature thermal and x-ray phase analyses established that the compound $ZrCr_2$ exists in two polymorphic modifications: in a high-temperature [structural type $MgZn_2(C_{14})$], and in a low-temperature [structural type $MgCu_2(C_{15})$] modification. The temperature of the polymorphic transformation is 1480 ± 10°C. The intermetallic compounds $TiCr_2$ and $ZrCr_2$ are isomorphous in both polymorphic modifications. The phase diagram of the $TiCr_2$–$ZrCr_2$ system was plotted. This phase diagram is characterized by the presence of a continuous series of solid solutions between the high-temperature and low-temperature isomorphic modifications of the compounds. (Rev.Met.Lit.)

2660 THE PROCESS OF PRECIPITATION IN Cu–Be 25 ALLOY. Henmi, Zenzo; Nagai, Takeshi. Nippon Kinzoku Gakkaishi, 30: 857-62(1966). (In Japanese).

The process of precipitation in Cu–Be 25 alloy is examined by the transmission electron microscope. The aging sequence of Cu–Be 25 alloy is the same as Cu–2% Be alloy, $\alpha \rightarrow$ G.P. zone $\rightarrow \gamma' \rightarrow \gamma$ in grain and $\alpha \rightarrow \gamma$ at grain boundary; but the aging sequence of Cu–Be 25 alloy is slower than Cu–2% Be alloy. The detail of aging sequence is different; for example, the product of the grain boundary reaction has internal stress or the over-aged Cu–Be 25 alloy has an anomalous electron diffraction pattern. (Rev. Met. Lit.)

2661 ELECTRON METALLOGRAPHY TECHNIQUES APPLIED TO BODY-CENTERED-CUBIC METALS AND ALLOYS. Koegan, W. A.; Karg, A. V.; Fornwalt, D. E. Norelco Rep., 13: 67-72(July-Sept. 1966).

Electrolytic thinning was used to prepare Nb, Ta, Mo, W, Nb–Zr, Nb–Zr–C, Nb–W–Zr, Nb–Mo, Nb–Mo–Zr–Ti, Mo–Ti, and Nb–W–Hf–C thin foils without altering the bulk microstructure. Preferential etching at the edges of the material is eliminated by coating the edges with a nonconducting lacquer. Foils were thinned from sheet material, ingot sections, Instron tensile specimens, longitudinal sections of tubing and lengths of 0.03-in. dia wire. Typical micrographs are illustrated for studying work-hardening and dispersion-hardening mechanisms in the bcc metals and alloys. The method was also used for investigations correlating alloy structure with performance in test systems. (Rev. Met. Lit.)

Radiation Effects

Refer also to abstracts 2620 and 3204.

2662 (BNWL-479) IRRADIATION BEHAVIOR OF ZIRCALOY-2 CLAD THORIUM–URANIUM–ZIRCONIUM FUEL ELEMENTS. Interim Report No. 1. Goffard, J. W.; Marshall, R. K. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Sept. 1967. Contract AT(45-1)-1830. 29p. Dep. CFSTI.

Seven tubular Th–2.5 wt % enriched U–1.0 wt % Zr alloy fuel elements are being irradiated under water cooled power reactor conditions. Irradiation performance of these Zircaloy-2 clad elements has been excellent to burnups of 2.1 at. % of the total atoms (18,600 MWd/t). Measured volume expansion of the alloy fuel has been at a rate approximately equal to that expected from the solid fission fragments. One element was destructively examined after an exposure of 1.4 at. % burnup (12,000 MWd/t). No evidence of fuel porosity was found, and little evidence of crystallographic damage was noted in the structure of the fuel. It is expected from existing data that the fuel will readily achieve 3.0 at. % burnup

under water cooled power reactor conditions. Irradiation is continuing toward this goal exposure. (auth)

2663 (CU-3551-7) RADIATION DAMAGE IN PLATINUM. Final Progress Report (Part 1). Attardo, Michael (Columbia Univ., New York. School of Mines). Feb. 1967. Contract AT(30-1)-3551. 120p. Dep. CFSTI.

Thesis.

Defects introduced into 99.9998% pure platinum by fast neutron irradiation have been studied by field-ion microscopy and tensile testing. A large variety of defects have been observed in the irradiated crystals. Damaged or depleted zones have been identified and their concentration and size has been studied as a function of annealing temperature. The observed density and size distribution of these defects agrees with the neutron energies and total exposures used. In the irradiated crystals, the yield stress recovers in two distinct recovery stages, occurring at 200 to 300°C and 500 to 600°C. The first stage exhibits an activation energy of 1.5 ± .2 eV. The recovery stages are associated with the removal of single vacancies and the removal of depleted zones as followed by field ion microscope observations. Stage III recovery in platinum has also been studied by examining specimens irradiated at temperatures above and below stage III recovery. Direct observation indicates that some form of interstitial atom motion must be associated with this recovery stage since the configuration of the interstitial atom resembles that of the split or dumbbell interstitial configuration. Investigation of the interstitial atoms formed at 4.2°K reveals a different form of interstitial configuration. The observations give direct confirmation of the two interstitial model of radiation damages in face-centered cubic metals. Measurements of the single vacancy concentration on the {102} plane in well-annealed platinum, as revealed by field ion microscopy, are abnormally high (from 1 to 20×10^{-3}). An investigation indicates that such vacancies are introduced by the field evaporation process. This observation precluded the study of individual lattice vacancies, as introduced by irradiation, with the field ion microscope. (auth)

2664 (CU-3551-8) VACANCY ANNEALING IN IRRADIATED TUNGSTEN. Final Progress Report (Part 2). Jeannotte, Dexter A. (Columbia Univ., New York. School of Engineering and Applied Science). 1967. Contract AT(30-1)-3551. 56p. Dep. CFSTI.

Thesis.

Vacancy removal in irradiated tungsten has been studied by direct observation with a field ion microscope. This direct observation of the vacancy fraction has established the following: Vacancy migration is responsible for the decay in resistivity of irradiated tungsten near 900°C. In this temperature region vacancies migrate with an activation energy of approximately 3.3 eV, following first order kinetics. The number of jumps to annihilation for a migrating vacancy is indicated to be approximately 10^4. The sink density in irradiated materials is likely to be a function of radiation dose with approximately 10^{-8} sinks per fast neutron for doses less than saturation. Correlation of present results with previous work indicates that Stage III recovery in body centered cubic materials is probably due to an impurity-dislocation reaction. (auth)

2665 (N-67-16572) PROGRAM OF ANALYTICAL AND EXPERIMENTAL STUDY OF POROUS METAL IONIZERS. VOLUME I. Summary Report, April 5, 1965–May 5, 1966. Shelton, Haywood; Hall, David F. (TRW Systems, Redondo Beach, Calif. Electric Propulsion Technology Dept.). Jan. 22, 1967. Contract NAS3-7109. 132p. (NASA-CR-54694). CFSTI.

Cesium ion and neutral emission were measured from pure and alloyed porous metal ionizers at current densities up to 50 ma/cm. The neutral emission was measured as a function of the angle from the normal and found not to be distributed as the cosine, iridium, iridium–tungsten alloy, rhenium–tungsten alloy, and pure tungsten emitters were studied. In addition, the effects of Ta, Nb, Mo, Rh, Pt, C, Si and Al on the surface of porous W emitting cesium ions were studied. (auth)

2666 (NYO-3653-2) A STUDY OF RADIATION INDUCED DEFECTS IN METALS. Progress Report, November 6, 1966–November 3, 1967. Townsend, John R. (Pittsburgh Univ., Pa. Dept. of Physics). Contract AT(30-1)-3653. 27p. Dep. CFSTI.

Progress in low temperature irradiations of Cu and W and in computer simulations of defect metal lattices is reported. Both Cu and W show very low temperature anelastic processes which are stable at the temperatures of observation. In the case of Cu, a peak in internal friction occurs near 12° for vibrational frequencies near 1 kHz, appears to rise from a point defect produced by irradiation in a pure Cu lattice, has a neutral stress axis parallel to the ⟨100⟩ direction, corresponds with thermal activation energy of about 0.02 eV, and disappears in the temperature range associated with annealing stages I-D and I-E in electrical resistivity experiments. A corresponding W anelastic process has not been studied in such detail; it is found near 13 to 14°K at a frequency of 1 kHz, is stable until annealing near 25°K, and is apparently due to an irradiation produced defect in the pure W lattice. Elastic bulk effects in Cu and W are negative even when irradiation occurs at 15 to 20°K and measurements are made at liquid He temperature. This result is now believed to be due to anelastic processes active even at 4.2°K. Computer programs are available for simulating atomic lattices by using two body interaction potentials and long range cohesive forces. The lattice can be imbedded in an infinite blanket of elastic continuum, or it can have a blanket of finite thickness. The latter case is useful in investigating the effect of the defects on the elastic constants. As an example of this type of calculation, it has been found that one atomic percent of vacancies in tungsten would raise the bulk modulus by 1.9 per cent demonstrating the importance of image force terms in elastic bulk calculations. Progress on piezo-resistance measurements has been slight. The mechanical drive has been replaced by an electromagnet drive and circuit fluctuations reduced sufficiently to reach the goal of 1 microvolt sensitivity. Carbon and nitrogen doped Fe wires are on hand to test the apparatus. (auth)

2667 (ORO-3612-4) AN INVESTIGATION OF IRRADIATION STRENGTHENING OF B.C.C. METALS AND SOLID SOLUTIONS. Progress Report, January–October 1967. (Maryland Univ., College Park). Nov. 1967. Contract AT(40-1)-3612. 4p. Dep. CFSTI.

Impure polycrystalline V samples irradiated at 2.8×10^{19} and 2×10^{20} nvt in the CP-5 reactor were investigated. Results were similar. No change in the rate controlling mechanism of slip was found. Samples of the lower dose rate were tested in tension but those in the higher dose rate were tested in compression in a specially designed rig. High purity single crystals have been irradiated and will be investigated when they are less radioactive. (F.S.)

2668 HIGH-TEMPERATURE TENSILE PROPERTIES OF NEUTRON-IRRADIATED 20Cr–35Ni AUSTENITIC STEEL. Roy, R. B.; Solly, B. Z. Metallk., 58: 258-62(Apr. 1967).

The embrittlement of 20 Cr–35 Ni austenitic steel in the unirradiated condition at temperatures of 750°C and above is due to the formation and link-up of grain boundary cavities. Grain boundary precipitation due to prolonged annealing at 650°C has no significant effect on the tensile properties. At 750 and 820°C the increased embrittlement of irradiated specimens is due to an increase in the nucleation and growth rate of grain boundary cavities. It is suggested that this is due to He atoms produced during irradiation migrating to the grain boundary cavities and thus decreasing both the critical radius and external stress needed for cavity growth. Presence of Li at grain boundaries reduces the surface energy and facilitates nucleation and growth of cavities. Irradiation induced reduction in ductility at 650°C tests in this alloy is caused by catastrophic growth of triple point wedge cracks. Presence of Li and He atoms at the grain boundary due to transmutation of B is responsible for catastrophic growth of these cracks. (Rev. Met. Lit.)

2669 DISTRIBUTION OF BORON IN AN AUSTENITIC STEEL INFERRED FROM THE OBSERVATION OF HELIUM GAS BUBBLES AFTER NEUTRON IRRADIATION. Woodford, D. A. (General Electric Co., Schenectady, N. Y.); Smith, J. P.; Moteff, J. Contract AT(40-1)-2847. J. Nucl. Mater., 24: 118-20(1967).

It is concluded that boron is contained principally in the form of a Ti(NB) precipitate in A-286 alloy. An obvious mechanism for the improved ductility with boron additions for unirradiated alloys is not provided, nor does it eliminate the possibility of a highly localized grain boundary segregate of a few atom spacings. (J.C.W.)

2670 IRRADIATION CREEP IN SEVERAL METALS AND ALLOYS AT 100°C. Lewthwaite, G. W. (United Kingdom Atomic Energy Authority, Dounreay, Scotland); Mosedale, D.; Ward, I. R. Nature (London), 216: 472-3(Nov. 4, 1967).

The results of an experiment designed to compare the irradiation creep of a number of metals and alloys are described, including the effects of differing metallurgical condition. The metals examined were Mo, Ni, Ti, Nimonic alloys PE16 and 80A, and an AISI type 316 stainless steel, in the form of helical springs of 0.5 in. dia, wound from wire 0.04 in. dia. Irradiation was in a D_2O-flooded thimble in a hollow fuel element in the DMTR at Dounreay. The neutron dose, after about 2,000 hr irradiation, was 3×10^{20} nvt (>1 MeV), at the centre line of the apparatus employed. Linear creep was observed for Ni, Nimonic 80A, Nimonic PE16 in the fully heat-treated condition, and Ti. The Ti plots passed through the origin, but the lines for the other three materials made posi-

tive intercepts with the strain axes, suggesting the existence of a transient between zero dose and the first measurement at 6×10^{19} nvt. The stainless steel specimens showed entirely transient forms. The observed transient deflexions, steady-state deflexion rates, and total creep strains are tabulated. In magnitude the pure metals showed the greatest creep. The stainless steel showed small creep strain and early saturation. Comparison of cold-worked and annealed stainless steel specimens indicated that the former shows more irradiation creep, although stronger in thermal creep at temperatures below which recovery occurs. This inversion was also observed in Nimonic PE16. The Ti springs twisted in the horizontal plane, apparently linearly with time; possible reasons for this are discussed. Meaningful results could not be obtained for Mo springs, which were found to be disappearing rapidly, presumably by radiolytic oxidation. (auth) (UK)

2671 BEHAVIOR OF 9 PERCENT NICKEL STEEL IN REACTOR ENVIRONMENT. Cowan, A.; Fearnehough, G. D.; Nichols, R. W. Lastechniek, 32: No. 3, 45-50(Mar. 1966).

Tests were made on 9% Ni steel to establish its suitability for use as reactor pressure vessel material. Fabrication and welding of thick sections appear to be satisfactory although some further development is necessary. However, both irradiation and thermal stability tests show large increases in transition temperature. It is likely that after few years' operation at about 300°C, advantage over mild steel vessels of low transition temperature would be lost because of these large embrittling effects. (Rev.Met.Lit.)

2672 THE EFFECT OF NEUTRON IRRADIATION ON THE THERMAL STABILITY OF CEMENTITE IN WHITE CAST IRON. Mitsche, R.; Maurer, K. L.; Bach, J. Berg- Huettenmaennische Monatsh., 111: 104-11(Mar. 1966). (In German).

Cast iron specimens containing 2.91% C, 0.71% Si, 0.55% Mn, 0.058% P, 0.198% S, and 0.01% Cr are subjected to neutron irradiation during vacuum annealing procedures at 750 to 850°C. Different neutron doses are applied. The effect of neutron irradiation on microstructure reactions with emphasis on cementite stability is investigated by microstructure analysis. It is found that particle number and size of elementary carbon particles that form by cementite decomposition are strongly affected by neutron irradiation. Neutron irradiation results in an increase in diffusion kinetics of carbon. Grinding and fracture tests show that the mechanical properties differ strongly between specimens in which graphite was formed by cementite decomposition under the influence of neutron irradiation as compared to nonirradiated specimens. (Rev.Met.Lit.)

2673 NEUTRON IRRADIATION AND THE YIELD SURFACES OF COPPER. Dudderar, Thomas Dixon. Providence, Brown Univ., 1966. 83p.

Thesis.

Tests were conducted to determine the effects of irradiation and plastic deformation on the yield surfaces of polycrystalline copper. It was found that the principal effect of plastic deformation on unirradiated copper was to translate the yield surface without appreciably changing its size or shape. Irradiation, on the other hand, produced a very large change in the overall size of the initial yield surface; in other words, produced an effect phenomenologically similar to extensive isotropic strain-hardening. In addition, the shape of the initial yield surface after irradiation was dependent on the plastic strain offset chosen to define yield. This effect was not observed for the unirradiated metal. Extensive plastic deformation after irradiation caused the yield surface to translate and grow smaller without significantly changing shape. (Disser. Abstr.)

Ceramics and Cermets

Refer also to abstracts 2087 and 2560.

2674 MATERIALS FOR ENGINEERS. PART 8. BERYLLIUM OXIDE. Livey, D. T. Engineer, 223: 347-9(Mar. 3, 1967).

The occurrence and extraction, fabrication, properties, and applications of BeO are described. Steps involved in fabrication by die pressing and sintering, extrusion and sintering, slip casting and sintering, and hot pressing are indicated. Properties stated include permeability for viscous flow, density, porosity, corrosion resistance, toxicity, electrical resistivity, thermal linear expansion coefficient, thermal conductivity, modulus of rupture, compressive strength, Young's modulus, alpha-beta transition temperature, melting point, Poisson's ratio, specific heat, dielectric constant, dielectric loss, electric strength, grain size, and hardness. BeO has applications in the nuclear, electrical, and electronic industries and is generally useful for high-temperature work, as a crucible for melting reactive metals and as a thermocouple insulator. (Rev. Met. Lit.)

2675 DISPERSION STRENGTHENED CERAMICS. Whalen, T. J.; McHugh, C. O.; Humenik, M. Jr. pp 219-27 of Strengthening Mechanisms: Metals and Ceramics. Syracuse, N. Y., Syracuse University Press, 1966.

A dispersion of metallic particles in ceramics can be used to control grain growth, and thus indirectly strengthen ceramic materials. Fine Mo particles have been found to inhibit grain growth and secondary recrystallization in aluminum oxide during sintering. Specimens with up to 10 vol % Mo have been fabricated by conventional powder metallurgy techniques. Three possible process methods can be used to disperse the Mo and the microstructures resulting from the different processes are discussed. Grain refinement from the metallic inclusions enhances the strength of aluminum oxide. (Rev. Met. Lit.)

Corrosion and Erosion

2676 STUDY OF THE OXIDATION OF AMORPHOUS BORON. Donnet, J. B.; Messiet, J. (Ecole Superieure de Chimie, Mulhouse, France). Bull. Soc. Chim. Fr., 8: 2963-7(Aug. 1967). (In French).

In a previous study, it was pointed out that the oxidation of amorphous boron by sulfuric acid leads to the formation of intermediate products in which boron has an average degree of oxidation below 3. In the present work, other oxidizers were studied. The results obtained with HNO_3, Fe^{3+}, I_3^-, Sn^{4+}, and $Fe(CN)_6^{3-}$ show that only the use of Fe^{3+} gives results comparable to those obtained with sulfuric acid. (auth)

Preparation and Fabrication

Refer also to abstracts 2034 and 2590.

2677 HIGH-PRESSURE SINTERING OF WC POWDER AND WC–Co MIXED POWDER. Kudaka, Katsuya; Koono, Hiroshi. Trans. Jap. Inst. Metals, 8: 207-8(July 1967).

The effects of pressures of 15 to 45 kbar on sintering WC powder and on mixed WC–Co power was investigated. It was found that both powders sintered at lower temperatures when pressure was high than when the pressure was at atmospheric. High pressure sintering of WC–Co mixes occurs at 600 to 1600°C. WC sinters at 1500°C under 15 kbar pressure and at 1600°C under 45 kbar pressure. (J.R.D.)

2678 BOROTHERMIC PREPARATION OF TITANIUM, ZIRCONIUM, AND HAFNIUM DIBORIDES. Peshev, P.; Bliznakov, G. (Inst. of General and Inorganic Chemistry, Sofia). J. Less-Common Metals, 14: 23-32(1968).

The formation of titanium, zirconium, and hafnium diborides by reaction between metal dioxides and elemental boron in vacuum in the temperature range 1000 to 1750°C has been investigated. It has been established that titanium diboride with a composition close to that of stoichiometric TiB_2 is obtained after a heat treatment of the reactants at 1700°C for 1 hr; HfB_2 is obtained after heat treatment at 1750°C for 2 hr. Experimental results showed that higher temperatures are necessary for the preparation of stoichiometric ZrB_2 by the borothermic method. The structure of HfB_2, and its stability at boiling point and at room temperature in the presence of acids, mixtures of acids, mixtures of acids with oxidizing agents, and alkaline solutions has been studied. (auth)

2679 FABRICATION OF UO_2 FUEL ROD BY VIBRATORY COMPACTION. Maruya, Kazuo; Osawa, Yasutaka; Aizawa, Takeshi; Takahashi, Shuichiro (Mitsubishi Atomic Power Industries, Inc. Omiya, Japan). J. Nucl. Sci. Technol. (Tokyo), 4: 528-39(Oct. 1967).

A fabrication technique, applicable to various vibratory compaction fuel rods is described. Some requirements governing the compaction of long size fuels to high density are specified. Compaction to 85 to 89% theoretical density was possible even using firm fused UO_2 powder of homogeneous particle size. Addition of 35% of highly fired UO_2 (−20 to ~ +325 mesh) to coarse fused UO_2 (−3 to ~ +10 mesh) shortened the compaction time, and improves the reproducibility of the final compaction densities. The addition of a loading weight on top was effective in raising the density when starting with powders of single particle size and in small quantity, but the effect became minor for mixed powders and in large quantity compaction. The quantity charged is one of the major factors determining the vibration time required to obtain high density of compact. Increase of impact force resulted in higher densities with the effect of crushing and compression of UO_2 particles. Vibswaging also improved density distribution. (auth)

2680 THE INFLUENCE OF FREQUENCY AND ACCELERATION DURING VIBRATIONAL COMPACTION ON THE DENSITY OF COMPACTED CERAMIC OXIDES. Zivanovic, B.; Ristic, M. M. Interceram. (Luebeck, Ger.), 16: No. 1, 66-8(Mar. 1967).

The influence of frequency on density during vibrational compaction is shown graphically for SiO_2, TiO_2, Al_2O_3, MgO, CuO and UO_2. The influence of changing acceleration on densities of SiO_2 and UO_2 is shown. Density is shown to continually increase with increasing power of vibrator. Vibratory apparatus used in investigation is shown and described. Most favorable working conditions are summarized which include a frequency range of 2500 to 400 Hz, acceleration range of 40 to 100 g, maximum power of vibrator and a compaction time of 5 min. (Rev.Met.Lit.)

2681 MICROSTRUCTURE AND PROPERTIES OF TUNGSTEN CARBIDE–COBALT HARD ALLOYS, THEIR MUTUAL EFFECTS AND THEIR DEPENDENCY ON THE INITIAL POWDERS. Mitsche, R.; Fischmeister, H.; Exner, H. E. Berg- Huettenmaennische Monatsh., 111: 138-46(Mar. 1966). (In German).

WC-Co cermets are prepared by powder metallurgical means. Powder mixtures of 90% WC and 10% Co are obtained by grinding these materials in alcohol with a ball mill. The obtained powders are analyzed chemically by X-ray and by electron microscopy. Also measured is the coercive force of the Co powders used as raw materials. From these powder mixtures, powder compacts are prepared and sintered in order to obtain cermets. Sintering takes place at 1190 to 1480°C. During these sintering tests shrinking is measured quantitatively. A series of mechanical tests is performed including the investigation of bending strength. Vickers hardness and coercive force. These properties are related to characteristics of the powders used in preparing the sintered compounds and to microstructure phenomena. Also analyzed are shrinkage characteristics as a function of sintering temperature. (Rev. Met. Lit.)

2682 STUDIES OF SILVER AND SODIUM NIOBATES. II. SODIUM NIOBATES AND MIXED SODIUM–SILVER NIOBATES. Brusset, Henry; Gillier-Pandraud, Helene; Belle, Jean-Pierre (Faculte des Sciences, Paris). Bull. Soc. Chim. Fr., 8: 2784-7 (Aug. 1967). (In French).

In the course of preparations carried out in the binary system $Na_2O-Nb_2O_5$, for proportions $Na_2O:Nb_2O_5$ below 1:1, three niobates are identified, only one of which is known with certainty: Na_2O, 2 Nb_2O_5; Na_2O, 4 Nb_2O_5; and Na_2O, 3 Nb_2O_5. A synthesis of mixed silver-sodium metaniobates was developed by means of two different processes. (auth)

2683 PREPARATION OF BORON SELENIDE, B_2Se_3. Cueilleron, Jean; Hillel, Roger (Faculte des Sciences, Lyon). Bull. Soc. Chim. Fr., 8: 2973-6(Aug. 1967). (In French).

Boron selenide, B_2S_3 was prepared, either by the action of selenium on boron in a sealed bulb (the bulb being internally protected by a carbon film since boron selenide reacts with silica, giving silicon selenide and boron anhydride), or by the action of a mixture of hydrogen selenide and hydrogen boride on boron between 850 and 950°C. The products obtained contain selenium in excess, which is not totally eliminated by sublimation. Processes are described that lead to the isolation of boron selenide, which is identified by its x-ray diffraction spectrum and its infrared absorption spectrum. (auth)

2684 HIGH-PRESSURE, HIGH-TEMPERATURE CERAMIC STRUCTURES. Clougherty, Edward V.; Kalish, David. pp 431-43 of Strengthening Mechanisms: Metals and Ceramics. Syracuse, N. Y., Syracuse University Press, 1966.

High-pressure hot pressing, a fabricating procedure that uses pressure of the order of 100,000 psi and temperatures from 1500 to 2000°C, has been used to prepare dense samples of transition metal diborides, TiB_2 and ZrB_2, without lower-melting metal additives. The microstructural characteristics of these materials are presented and are correlated with measured mechanical property data. Complementary analyses are also presented for materials fabricated by conventional hot pressing. (Rev. Met. Lit.)

2685 TECHNOLOGY OF UO_2 SINTERING. Ristic, M. M.; Radic, S. Interceram (Luebeck, Ger.), No. 2, 145-6(July 1966).

A method of sintering UO_2 pellets for nuclear fuel applications, using water as the binder in optimum ratios of 4–6% by weight, is described. Powder, obtained from uranium nitrate by way of ammonium diuranate, is mixed with water, granulated and pressed at an optimum pressure of 2 ton/cm^2. The pellets are dried in vacuo for 2 hr at 100°C. Average compact density is 5.1 ± 0.1 g/cm^3 and the average diameter 15.15 mm. Densities of 96% of theoretical are obtained. Sintering is performed for 4 hr in dry hydrogen at 1550°C. Maximum deviation from the average diameter is ±0.17%; 68% of the pellets had diameters within 11.90 ± 0.05 mm. (Rev. Met. Lit.)

2686 FUEL PELLET FOR NUCLEAR REACTOR. Ockert, Carl E. (to U. S. Atomic Energy Commission). U. S. Patent 3,356,584. Dec. 5, 1967.

Improved ceramic fuel pellets for use in rod-type nuclear reactor fuel elements are described. Longitudinal slots are provided in the inner and/or outer surfaces of the annular-shaped pellets in order to decrease the effect of pellet temperature or irradiation induced growth in creating tensile hoop stresses in the tubular cladding enclosing the pellets. (auth)

Properties Evaluations

Refer also to abstracts 2036, 2053, 2621, and 3158.

2687 (N–67-15390) MULTIDISCIPLINARY RESEARCH ACTIVITY IN THE MATERIALS SCIENCES WITH EMPHASIS ON CERAMIC MATERIALS. Semiannual Status Report, June 16–December 15, 1966. Mueller, James I. (Washington Univ., Seattle. Div. of Ceramic Engineering). 37p. (NASA-CR-81163; SASR-7). CFSTI.

Summary reports are given on continuing research in the field of ceramics and ceramic engineering, including chemistry, surface phenomena, solid state ceramics, processing, and radiation effects. Topics covered in the investigation of the zirconium–oxygen–carbon system were gas–solid equilibrium, solid–solid equilibrium, calorimetric study of ceramics and related materials, thermodynamics of ternary ceramic phase diagrams, and zirconium oxidation. In the study of solid state ceramics, the areas covered include ferroelectric materials, domain dynamics in isomorphous ferroelectrics, phase topography, Mossbauer studies, defect properties, and mechanisms of deformation. Aluminum oxide bicrystals, surface diffusion, and the use of ceramics in controlling antenna system parameters were studied in the field of surface phenomena. Investigation of the effects of radiation on ceramic materials centered on ultraviolet photolysis of ceramic materials, and processing studies included ceramic processing, and the effects of lanthanum doping on barium titanate. (TSS)

2688 (WAPD-TM-649) CONTINUUM DILATATION MODEL FOR CREEP SWELLING OF CERAMIC NUCLEAR FUELS WITH APPLICATIONS (LWB–LSBR DEVELOPMENT PROGRAM). Small, N. C. (Bettis Atomic Power Lab., Pittsburgh, Pa.). Sept. 1967. Contract AT(11-1)-Gen-14. 44p. Dep. cfsti.

A continuum model is presented for the creep swelling of ceramic nuclear fuel materials. The theory includes the effects of fabricated porosity, as well as fission induced porosity and surface tension. A central feature is the use of a macroscopic dilatational element in the form of a hollow sphere in which the central cavity plays the role of a large fabricated pore and the annulus contains fission gas pores which are, in turn, represented by analogous microscopic hollow spherical elements. For simplicity, one-dimensional strain is assumed and the resulting equations are applied to the densification and swelling of fuel plates as well as to the problem of sintering and hot pressing. Viscous behavior (creep exponent n = 1) is assumed throughout the analysis except for the hot pressing example which is solved for an arbitrary n. The fuel plate problem is solved numerically by use of an IBM 7040 computer; an analytic solution is presented for sintering and a partially analytic approach is used for the hot pressing case. Several parametric studies are carried out for the fuel plate which show the effects of viscosity, initial fission pore spacing, and external (loop) pressure. A good correlation is obtained with existing ZrO_2-UO_2 plate swelling data. (auth)

2689 METHODS OF CALCULATING MELTING-POINT DIAGRAMS FOR BINARY OXIDE SYSTEMS. Reichelt, W.; Gross, B. (Technische Univ., Berlin). Chem.-Ind.-Tech., 39: 1175-9(Oct. 1967). (In German).

The known thermodynamic expressions for calculating the melting point diagrams of binary systems differ according to the miscibility of the components in the liquid or solid state. The melting point diagrams for $Al_2O_3-UO_2$, $MgO-UO_2$, UO_2-SiO_2, UO_2-BeO, $BeO-SiO_2$, and those for UO_2-ThO_2, ZrO_2-BeO, and $MgO-BeO$ are calculated and compared with the experimental diagrams. (auth)

2690 MEASUREMENT OF THE DIFFUSION PARAMETERS OF ZIRCONIUM HYDRIDE BY MEANS OF THE PULSED-NEUTRON SOURCE METHOD. Stumbur, E. A.; Matveenko, I. P.; Shokod'ko, A. G. At. Energ. (USSR), 23: 154-5(1967). (In Russian).

The accuracy of diffusion parameter measurements may be improved if at least two of the stationary, pulsed, and exponential neutron source methods are used in the determinations. For this reason, the mutually complementary pulsed and exponential methods were used for determining the diffusion parameters of $ZrH_{1.91}$, examining the dependence of the neutron pulse attenuation decrement, α, on the geometric dimensions of the moderator block. Parallelepiped-shaped specimens were used within the buckling

range of $B^2 = 0.02$ to $0.2\ cm^{-2}$. The zirconium hydride block and the boron detector were placed in a container shielded by paraffin, boron carbide, and cadmium keeping out scattered neutrons. The attenuation and the effective diffusion length were measured by means of a time analyzer with a time resolution of 8 μ sec. The following parameters were obtained for the 5.05 g/cm^3 $ZrH_{1.91}$ at 15°C: $(\Sigma_a \nu)_s = (5777 \pm 36)\ sec^{-1}$; $D_0 = (0.354 \pm 0.005) \times 10^5\ cm^2/sec$; $C = (0.24 \pm 0.05) \times 10^5\ cm^4/sec$. These values agreed with earlier data. The first two values represent moderator parameters for the equilibrium spectrum in an infinite medium. (TTT)

2691 MECHANICAL PROPERTIES OF NIOBIUM–HYDROGEN ALLOYS. Sasaki, Yasuo; Kimura, Hirozo; Uehara, Shigeaki. Nippon Kinzoku Gakkaishi, 31: 401-5(Apr. 1967). (In Japanese).

Tensile and bending properties of Nb containing H_2 up to 8 at. % were investigated. Hydrogen had a pronounced effect on elongation, yield stress and bending property of Nb. Niobium-hydrogen alloys were made by heating Nb in purified H_2 at 1 atm pressure at 450°C for several hours. Plate-like and lenticular hydrides were observed in all specimens used for the experiments. The yield stress and elongation of specimens were measured with Instron-type test machines at room temperature, −75 and −195°C. The yield stress increases gradually with increasing H_2 content. Elongation decreases with increasing H_2 content and Nb-2.05 at. % H_2 specimens showed 17% elongation, which was a half of that in pure Nb. Bend angle tests were carried out with Chevenard's testing machine at room temperature and a marked effect of H_2 on the bending properties was found. The bend angle decreased abruptly to zero in alloys containing more than 2.05 at. % H_2. Alloys containing less than 1.63 at. % H_2 showed ductile deformation in the bend test. (Rev. Met. Lit.)

2692 TRANSPARENCE LIMITS OF INTERFERENCE FILMS OF HAFNIUM AND THORIUM OXIDES IN THE ULTRAVIOLET REGION OF THE SPECTRUM. Sviridova, A. A.; Sulkovskaya, N. V. Opt. Spectrosc. (USSR) (Engl. Transl.), 22: 509-12(June 1967).

Translated from Opt. Spektrosk., 22: 940-5(June 1967).

Results are presented of an investigation of the transparency limit of films of hafnium and thorium oxides for uv radiation as functions of the temperature to which they are heated, and of the structure and chemical composition of the initial film-forming material. An influence of the presence of Cl^- and NO_3^- ions is demonstrated. (auth)

2693 DIFFUSION OF β-ACTIVE PRODUCTS OF NUCLEAR FISSION IN $\alpha-Al_2O_3$ SINTERED BODIES. Fiedler, W.; Grass, F. (Oesterreichische Hochschule, Vienna). Atomkernenergie, 12: 420-4(1967). (In German).

The diffusion of thermostable oxides of fission products was by means of ^{95}Nb, ^{141}Ce, ^{147}Pm, and ^{153}Sm tracers in polycrystalline $\alpha-Al_2O_3$. The diffusion coefficients are given by the equations: $D_{Nb} = (1.56 \pm 0.75) \cdot 10^5 \cdot \exp(-(126{,}000 \pm 5090)/RT)\ cm^2sec^{-1}$, $D_{Ce} = 2.93 \cdot 10^3 \cdot \exp(-111{,}000 \pm 8000)/RT)\ cm^2sec^{-1}$, $D_{Pm} = 2.82 \cdot 10^5 \cdot \exp \cdot (-(134{,}500 \pm 8900)/RT)\ cm^2sec^{-1}$, and $D_{Sm} = 2.63 \cdot 10^{13} \cdot \exp \cdot (-(181{,}500 \pm 13{,}000)/RT)\ cm^2sec^{-1}$. A comparison with the diffusion of ^{147}Pm with an Nd carrier ($1:10^7$) shows that the diffusion of carrier-free ^{147}Pm is enhanced, and the diffusion of other rare earths shows an unexpectedly wide range of Q and D_0 values. (auth)

2694 EFFECT OF POROSITY ON THE THERMAL CONDUCTIVITY OF UO_2. MacEwan, J. R.; Stoute, R. L.; Notley, M. J. F. (Atomic Energy of Canada Ltd., Ont.). J. Nucl. Mater., 24: 109-12(1967).

Cylindrical conductivity specimens 7.4 mm dia by 7.4 mm long were prepared from UO_2 fuel pellets. Grain size, pore structure, and macroscopic density were determined. A comparative, longitudinal heat-flow apparatus was used to measure the thermal conductivity at 60°C. A graph shows the variation of the thermal conductivity of UO_2 with pore volume fraction. (J.C.W.)

2695 CALCULATION OF THE TEMPERATURE-DEPENDENT SHEAR MODULUS OF UO_2. Sung, P.; Turnbaugh, J. E. (Univ. of Washington, Seattle). J. Nucl. Mater., 24: 107-8(1967).

Shear modulus is calculated from equations and shown graphically for the range 298 to 1800°K. (J.C.W.)

2696 EFFECTS OF THE CARBON CONTENT ON THE PROPERTIES OF WC–TiC–Co ALLOYS. Suzuki, Hisashi; Hayashi, Kozi. Trans. Jap. Inst. Metals, 7: 199-203(July 1966).

The effects of the binder composition in the cemented carbides have been investigated, and it is known that the binder composition or the carbon content of the alloys has a remarkable effect on the properties of the two-phase WC–Co alloys. In the present experiment, ordinary WC–TiC–10% Co alloys which contain 6 to 25% TiC in carbides and consist of (WC + beta + gamma) three phases were vacuum sintered. The carbon contents of the specimens were strictly controlled. The relation between the properties of the sintered alloys and the carbon content or the TiC content was examined. The lattice parameters of the gamma and beta phases showed a regular change in the three-phase region due to the change in composition in both phases. The W content in the binder phase of the three-phase alloys varied from 2 to 3% in minimum to 9 to 10% in maximum depending on the carbon content. The amount of W dissolved in the binder phase corresponded to the values in the WC–Co alloys. The addition of TiC resulted in an extreme extension of the three-phase range owing to the change in carbon content in the beta phase. The properties, such as transverse-rupture strength and magnetic saturation, varied regularly within the three-phase region. (Rev. Met. Lit.)

2697 REFRACTORY CORES FOR ANNULAR PELLET NUCLEAR FUEL ELEMENTS. Lang, J. E.; Wisnyi, L. G.; Ploetz, G. L. Contract W-31-109-eng-52. Ceram. Age, 82: No. 11, 42-5(Nov. 1966). (KAPL-P-3144).

ZrO_2, stabilized in the cubic phase with 5–10% CaO and formed into fibers, foams, bubbles, and low-density extruded rods, has been tested to determine its effectiveness as a mechanically compressible mandrel for use in rod-type nuclear fuel elements. Test conditions include exposure to pressurized hot water in a leaking fuel element, thermal cycling during reactor shutdowns, startups and transients, and the reaction of the mandrel to an applied compressive stress of about 1000 psi for accommodation of fuel swelling while minimizing the burden on the cladding. Also evaluated are the redistribution of cracked and spalled fuel pellet mockups into the mandrel material and the interdiffusion of fuel and mandrel materials at elevated temperatures. Results show that the ZrO_2 would be a suitable material for location centrally within an annular pellet type fuel element. The specific geometric shape depends on operating conditions of the fuel element. Principle advantage would be the accommodation of fuel swelling and prevention of undesirable mechanical relocation of cracked or spalled fuel. Use of ZrO_2 above 1700°C may necessitate use of a reaction barrier coating to prevent diffusion of uranium into the mandrel. The optimum configuration appears to be bubbles or hollow spheres. Optimum sphere size can be adjusted to reflect the inside diameter of the fuel annulus and predicted fuel swelling. Other oxides such as Al_2O_3 or ThO_2 could be used in specific applications. Thoria, for example, would fill the central void with a fertile (fuel breeding) material rather than an inert one. (Rev. Met. Lit.)

2698 STUDY OF CERAMIC MATERIAL BY HIGH-TEMPERATURE X-RAY ANALYSIS. Strekalovskii, V. N.; Bessonov, A. F.; Ust'yantsev, V. M.; Burov, G. V. pp 111-18 of Electrochemistry of Molten and Solid Electrolytes. Vol. 3. New York, Consultant's Bureau, 1966.

Described is the auxiliary device for high-temperature operation (up to 1300°C) with KROS inverse photography camera and URS-60 x-ray apparatus. Coefficients of thermal expansion are determined for several sintered oxides: CeO_2, CeO_2-SrO, $ZrO_2-Y_2O_3$, ZrO_2-CaO, and $ZrO_2-Nd_2O_3$. Values obtained are lower than values obtained dilatometrically. Transformation is observed during heating and cooling of $ZrO_2-Y_2O_3$ and $ZrO_2-Nd_2O_3$. Variation of the lattice constant of CeO_2 measured in air and in vacuum is explained as due to the formation of the solid solution of Ce_2O_3 in CeO_2 in vacuum. (Rev. Met. Lit.)

2699 PLUTONIUM REFRACTORY COMPOUNDS. Skavdahl, R. E.; Chikalla, T. D. (Battelle-Northwest, Richland, Wash.). pp 249-98 of Plutonium Handbook. A Guide to the Technology. Vol. I. Wick, O. J. (ed.). New York, Gordon and Breach Science Publishers, 1967.

The phase relations, crystallographic data, methods of synthesis, and various physical, thermodynamic, and chemical properties of the refractory compounds of Pu are described. These include the oxides, carbides, nitrides, silicides, sulfides, hydrides, borides, and phosphides. Since little is known about most of these compounds, most of the chapter is concerned with the oxides and carbides and alloys of these compounds with their U analog. A summary of the crystallographic data on the refractory compounds is given. Included also is a section covering the radiation self-damage in Pu compounds caused by α-disintegration of Pu. In most instances the information is current with the published literature through December 1963. (auth)

2700 ELECTRICAL RESISTIVITY, ELASTIC MODULUS AND DEBYE TEMPERATURE OF TITANIUM DIBORIDE. Vahldiek, F. W. J. Less-Common Metals, 12: 202-9(Mar. 1967).

Electrical resistivity measurements on single and polycrystalline specimens of TiB_2 at 293 and 77°K indicated a metallic-bonding mechanism. The average resistivity for single crystal TiB_2 is 6.6 microhm-cm at 293 and 1.1 microhm-cm at 77°K. Anisotropy of the resistivity values with respect to the c- and a-axes of TiB_2

(c/a = 1.067) was not observed. The random electrical resistivity of hot pressed specimens ranged from 9.1 microhm-cm at 293°K to 2.2 microhm-cm at 77°K. Anisotropy in elastic and shear moduli was determined to follow the lattice-parameter ratio. Debye temperature values were calculated from average rod-velocity measurements on single crystal bar and rod-shaped specimens resulting in values of 952 and 964°K, respectively. For polycrystalline TiB_2, the Debye temperature calculated from rod-velocity measurements ranged from 1100 to 1130°K. (Rev. Met. Lit.)

2701 EFFECT OF MICROSTRUCTURE ON CREEP MECHANISMS IN CERAMICS. Vasilos, T.; Passmore, E. M. pp 161-79 of Strengthening Mechanisms: Metals and Ceramics. Syracuse, N. Y., Syracuse University Press, 1966.

A review and assessment are given of literature pertaining to creep deformation mechanisms in polycrystalline ceramics (Al_2O_3, BeO, MgO, and SiC). The factors affecting creep, including crystal structure, composition, stress, temperature, grain size, subgrain structure, and porosity are discussed in detail. The most important mechanism is the stress-directed diffusional creep of the Nabarro–Herring type; however, in MgO and the halides, dislocation movement is also important. Changing stress or grain size causes transition to other creep mechanisms which probably involve dislocation movement. Further study on grain boundary creep and more comparative data of different materials, taken under similar conditions, are very much needed. (Rev. Met. Lit.)

2702 INVESTIGATION OF THE HEAT RESISTANCE OF BRITTLE POWDERED-METAL MATERIALS. Kravchuk, L. V. pp 244-9 of Termoprochnost' Materialov i Konstruktsiya Elementov. Kiev, Nauk Dumka, 1965. (In Russian).

The resistance to thermal shock of annular specimens from Mo with an addition of 2, 5, 10, 20, 30, and 40% Zr oxide was studied. The difference between the temperature of the heated specimen and the cooling air at which the breakdown occurs in one heating-cooling cycle is taken as a criterion for the resistance. Methods of simultaneous determination of the breakdown instant and of the resistance were developed. (Rev. Met. Lit.)

Structure and Phase Studies

2703 (KFK-597) PHASENGLEICHGEWICHTE IN DEN SYSTEMEN ThO_2–$HoO_{1.5}$($LuO_{1.5}$,$ScO_{1.5}$) UND $HoO_{1.5}$–UO_2(UO_{2+x}, NpO_{2+x}, PuO_{2+x}). (Phase Equilibrium in the Systems ThO_2–$HoO_{1.5}$($LuO_{1.5}$,$ScO_{1.5}$) and $HoO_{1.5}$–UO_2(UO_{2+x},NpO_{2+x}, PuO_{2+x})). Engerer, Hans (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Radiochemie). July 1967. 59p. (In German). Dep.

The phase behavior in the system ThO_2–$HoO_{1.5}$, ThO_2–$LuO_{1.5}$, ThO_2–$ScO_{1.5}$, UO_2–$HoO_{1.5}$, (U_x, Ho_{1-x})$O_{2.00}$, UO_{2x}–$HoO_{1.5}$, NpO_{2+x}–$HoO_{1.5}$, and PuO_{2+x}–$HoO_{1.5}$ were studied at 1,100 to 1,700°C. In the systems ThO_2–$HoO_{1.5}$($LuO_{1.5}$, $ScO_{1.5}$) the temperature dependence of the limiting compositions of the individual phases were determined at 1,250 to 1,700°C and the phase diagrams are given. The investigation of the equilibrium appearance of a mixture with 85 mol % ThO_2 and 15 mol % $HoO_{1.5}$ prepared from the oxide component shows as a function of time that in the transformation of the pure oxides a complete mixed crystal formation is obtained after a reaction time of approximately 2,000 hrs. The homogeneity ranges of the solid solution were smaller the larger the difference of the ion radii [$r_{Th^{4+}} - r_{Me^{3+}}$]. In the system ThO_2–$HoO_{1.5}$ the structure of the fluoride and sesquioxide mixed crystals was determined by comparison of the theoretically found densities with the experimental values. It was shown that in both mixed crystal types there is a completely filled cation partial lattice. The phase behavior of the systems UO_2(UO_{2+x})–$HoO_{1.5}$ was investigated at 1,100 to 1,550°C and at 1,250 to 1,550°C, respectively. The system (U_x, Ho_{1-x})$O_{2.00}$ was investigated at 1,100°C. In the system UO_{2+x}–$HoO_{1.5}$ the fluorite phase in the temperature range studied extends up to 64 mol % $HoO_{1.5}$. A homogeneous rhombohedric phase occurs between 72 and 85.7 mol % $HoO_{1.5}$. The rhombohedric compound $UO_2 \cdot 6HoO_{1.5}$ with pure hexavalent U is stable up to at least 1,400°C. The 1:1 composition is especially thermally stable since at all temperatures ($U_{0.5}$, $Ho_{0.5}$)O_x and O_2 number of x = 2.00 ± 0.02 occurs. The C-type phase is not strongly evident. The system (U_x, Ho_{1-x})$O_{2.00}$ occupies immediate and intermediate positions between the systems UO_2–$HoO_{1.5}$ and UO_{2+x}–$HoO_{1.5}$. A homogeneous cubic phase of pure UO_2 exists in the holmium oxide–uranium oxide system up to 53 mol % $HoO_{1.5}$. The systems NpO_{2+x}(PuO_{2+x})–$HoO_{1.5}$ were investigated at 1,100 to 1,700°C and the phase diagrams are given. In the system NpO_{2+x}–$HoO_{1.5}$ a rhombohedric 1:6 compound with the composition $NpO_3 \cdot 6HoO_{1.5}$ occurs, which is stable up to approximately 1,400°C. The compound possesses no phase width. On the basis of the high average valency of the Np in NpO_{2+x}–$HoO_{1.5}$ preparations the width of the C-type phase is very small as in the system UO_{2+x}–$HoO_{1.5}$. In the PuO_{2+x}–$HoO_{1.5}$ mixed crystals the Pu is oxidized to valences >4. Because of the similar ion radius of [$r_{Pu^{4+}}$ and $r_{Ho^{3+}}$] the fluorite and C-type phases extend over a wide range. A new family of rhombohedric 1:6 compounds of the type $NpO_3 \cdot 6MeO_{1.5}$(Me = rare earths and Y) was found. They are isostructural with the corresponding U compound. Between the mol volume of the 1:6 Np compounds and the ion radius of the corresponding trivalent metals there is a linear dependence. (tr-auth)

2704 CHEMICAL TRANSPORT REACTIONS IN THE VANADIUM–SILICON–OXYGEN SYSTEM AND THE TERNARY PHASE DIAGRAM. Spear, K. E. (Univ., Muenster, Ger. Univ. of Kansas, Lawrence); Gilles, P. W.; Schaefer, H. J. Less-Common Metals, 14: 69-75(1968).

Vanadium and silica glass react at 800 to 1200°C to form V_3Si(s) and VO(s) if the reaction vessel contains gaseous vanadium chlorides or iodides causing a chemical transport of the metal to the glass. In the presence of chloride species, V_3Si and VO are chemically transported from the hot to the cooler portions of the reaction vessel. The chemical reactions accounting for the transport are proposed. The following equilibrium tie-lines in the ternary V–Si–O phase diagram were determined: SiO_2–VO, SiO_2–V_3Si, V_3Si–VO, V_3Si–V_2O, and V_3Si–V_4O; and the phase diagram is presented. Considerations of the phase data and the heats of formation of VO(s) and SiO_2(gl) showed that $-\Delta H_f^0$ (V_3Si,s) must be >9 kcal/mole. Relative to one another, the set of values for the heats of formation of V_3Si, V_5Si_3, and VSi_2 as given in the literature was found to be thermodynamically inconsistent with V–Si–O phase data. (auth)

2705 CRYSTAL STRUCTURE OF NEODYMIUM GALLATE ($NdGaO_3$). Brusset, Henry; Gillier-Pandraud, Helene; Be Rdot, Jean-Louis (Faculte des Sciences, Paris). Bull. Soc. Chim. Fr., 8: 2886-90(Aug. 1967). (In French).

Determination of the structure of $NdGaO_3$ is based on x-ray diffraction by a monocrystal. The orthorhombic space group to be adopted is Pbn2, without any inversion center. The position deviations of atoms in comparison with those occupied in an ideal perovskite structure are specially large for the oxygen and gallium atoms. $NdGaO_3$ is noticeably different from $YFeO_3$ and $GdFeO_3$ although it belongs to the same structure type. (auth)

2706 $CrSi_2$–$MoSi_2$ DIAGRAM. Svechnikov, V. N.; Kocherzhinskii, Yu. A.; Yupko, L. M. pp 53-65 of Struktura Metallicheskikh Splavov. Kiev, Nauk Dumka, 1966. (In Russian).

Alloys of a $MoSi_2$–$CrSi_2$ section were annealed for 100 hr at 1350°C. The existence of a binary phase range between 40.5 and 70% $MoSi_2$ was verified by x-ray analysis. It was established by differential thermal analysis that the fusibility diagram refers to the peritectic type. The peritectic temperature was determined to be in the region of 1525 ± 25°C. (Rev. Met. Lit.)

Radiation Effects

Refer also to abstracts 2687 and 2699.

2707 (BNWL-SA-1346) PLUTONIUM FUEL IRRADIATIONS IN PRTR. Present Status. Freshley, M. D.; Burley, T. B.; Goldsmith, S. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Sept. 16, 1967. Contract AT(45-1)-1830. 18p. (CONF-671102-32). Dep. CFSTI.

From 15th Conference on Remote Systems Technology and Atom Fair, Chicago, Ill.

In an effort to develop inexpensive and safe methods of fabricating Pu fuels and to demonstrate performance characteristics of these fuels the Batch Core Experiment is being conducted to evaluate irradiation behavior of UO_2–PuO_2 fuel elements. Data on fuel elements operating at power generation rates greater than that currently employed in commercial power reactors is presented. The maximum allowable reactor power level based on maximum fuel temperature limit was determined. Gas release and pressure buildup in vibrationally compacted mixed-oxide fuel rods as a function of burnup and specific power was studied. Commercially designed and fabricated fuel rods containing hot pressed UO_2–PuO_2 pellets were tested. The dissolution behavior of unirradiated and irradiated mixed oxides in HNO_3 was studied. Defect behavior of full-sized PRTR fuel elements operating under power reactor conditions is being investigated. (F.S.)

2708 (EUR-3556f) DEGAGEMENT DU KRYPTON CONTENU DANS COUCHE MINCE DE MONOCARBURE D'URANIUM. (Release of Krypton Contained in a Thin Layer of Uranium Carbide). Schuerenkaemper, A.; Gautsch, O. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). Sept. 1967. 20p. (In French). Dep.

UC powders of different particle sizes were irradiated with thermal neutrons in presence of a few atmospheres Kr + ^{85}Kr.

After irradiation about 10^{13} atoms of Kr were found per cm^3 of the UC surface and per atmosphere of Kr-pressure at room temperature. During thermal annealing large fractions of the gas were released below 430°C. Between 430 and 1000°C the release rate seemed independent of the temperature. Above 1000°C the rates of emission increased again. From the release curves activation energies of 10 to 20 kcal/mole could be deduced for the low temperatures, and 62 to 85 kcal/mole for temperatures above 1000°C. (auth)

2709 (RT/FIMA-(67)2) CALCOLO DELLA PRODUZIONE E DELLA VELOCITA DI RILASCIO DI ALCUNI NUCLIDI DA UN ELEMENTO DI COMBUSTIBILE AD OSSIDO. (The Calculated Production and Release Rate of Several Nuclides From Oxide Fuel Elements). Cenacchi, G.; Segre, G. J. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). 1967. 27p. (In Italian). Dep.

The production of Ba, Cs, I, Kr, Rb, Sr, Te, Xe and their release rate from UO_2 fuel elements is calculated for irradiation times up to about five months. (auth)

2710 DIFFERENTIAL THERMAL ANALYSIS OF THE PHASE TRANSFORMATIONS OF THE TETRAIODIDES OF NATURAL URANIUM AND ^{233}U. Gagarinskii, Yu. V.; Khripin, L. A.; Polishchuk, S. A. At. Energ. (USSR), 23: 160-1(1967). (In Russian).

The energy of point defects created in radioactive materials by their own radiation exceeds the free energy and changes the physical and chemical properties of these materials. This question was examined by studying the buildup of structural defects of $^{233}UI_4$ under the influence of its own radiation. Attempts were made to correlate this effect with the changes in transformation temperatures. This material was chosen because it may be easily prepared from metallic U, it has a low transformation temperature and its entropy of transformation is known, although it presents a disadvantage in that the transformation temperature and the melting point are close. The heating and cooling curves were recorded with a precision of ±1°C; the material was heated and cooled at a rate of 4°C/min; aluminum oxide was used as the reference material. Reproducible thermic effects were noted in the differential thermal analysis curves of the tetraiodide of natural U at 472, 484, and 513°C; the highest of these values represented a melting point, the other two indicated crystalline transformation processes. The lower value, reported for the first time, corresponds to a polymorphic transformation of UI_4. Similar values were found with freshly prepared $^{233}UI_4$ but a small, although noticeable, exothermic effect was observed at a narrow range starting at 417°C corresponding to the annealing process. In view of the fact that the structural defects of UI_4 are annealed out before the polymorphic transformation temperature is reached the effect of the radioactivity of $^{233}UI_4$ on the phase transformation was not observed. (TTT)

2711 THE EFFECT OF NEUTRON IRRADIATION ON SOME MECHANICAL PROPERTIES OF DIAMOND. PART 2. THE POLISHING OF DIAMOND. Wilks, Eileen M. Ind. Diamond Rev., 27: 154-9(Apr. 1967).

Polishing tests were made on the cube, dodecahedron and octahedron faces of irradiated diamonds. Results show that cracking is produced in the surface layers, due primarily to the lattice having expanded during the irradiation. Subsequent annealing at 800°C for 2 hr restores the lattice parameter to its original value and there is no further cracking. As the hardness is not similarly restored by annealing, material can therefore be removed without complications in all directions on a cast iron polishing scaife. (Rev.Met.Lit.)

Plastics and Other Materials

Refer also to abstracts 3970 and 3979.

2712 (CEA-R-3226) DETERMINATION DE DOSES WIGNER DANS LE GRAPHITE. EFFET DE SPECTRE NEUTRONIQUE. (Determination of Wigner Doses in Graphite, Neutron Spectrum Effect). Genthon, Jean-Pierre (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). June 1967. 36p. (In French). Dep.

Various models representing the formation of Wigner defects are studied and compared. The Thompson-Wright model is chosen and this choice is justified. It is shown also that in the majority of cases of thermal neutron reactors, it is of no special use to know in detail the neutron spectrum to which the graphite is subjected, and that the Wigner dose W is given simply by a knowledge of the fast flux $\emptyset_r$ (E > 1 MeV) and of the flux per unit of lethargy at 1 keV, φ, measured using techniques which can today be applied in research reactors. $W/\emptyset_r$ is a logarithmic function, given here, of $\varphi/\emptyset_r$ for the electric collection of 40 spectra considered which obey the condition $0.07 \leq \varphi/\emptyset_r \leq 1.4$ (thermal neutron reactors). Finally, the constants required for calculating W directly from a known φ (E) spectrum are given. In particular, a very good approximation can be obtained by calculating the integral $\emptyset$ (Eo) = $\int_{Eo}^{\infty} \varphi$ (E) dE. The threshold Eo is given here for different types of reactor (~75 keV). (auth)

2713 (IN-1095) PENETRATION OF IODINE INTO PROTECTIVE COATINGS. Hammer, R. R.; Newby, B. J.; Rohde, K. L. (Idaho Nuclear Corp., Idaho Falls). Nov. 1967. Contract AT(10-1)-1230. 9p. Dep. CFSTI.

Of the radioactive isotopes which could be released to a reactor containment building as a result of certain nuclear reactor accidents, radioactive iodine is considered to be one of the greatest health hazards. The penetration of iodine into protective coatings characteristic of those used in reactor containment buildings has been studied. Penetration of iodine into the coating occurs with the paint coatings tested including epoxy, vinyl, chlorinated rubber, and phenolic. The penetration is at least in part reversible and the degree of penetration is associated with the temperature of the coating and its physical state. A model for unidirectional diffusion in a semi-infinite solid, derived from Fick's basic diffusion concepts, adequately describes the penetration of iodine into these coatings to thicknesses as great as 0.25 mm. Diffusivities for iodine (generated as I_2) in the protective coatings tested ranged from 10^{-8} to 10^{-10} cm^2-sec-1. Effects of coating type, additives, and exposure time are also reported. (auth)

2714 (R-67ND6) MOLD RELEASE CAPABILITY OF "TEFLON" FILMS FUSED ONTO METALLIC MOLDS. Holton, D. I. (General Electric Co., St. Petersburg, Fla. Pinellas Peninsula Plant). Oct. 10, 1967. Contract AT(29-2)-656. 10p. (GEPP-9). Dep. CFSTI.

Teflon film, applied as a fused coating to metal molds and gluing fixtures, can act as a release medium without adhering to an epoxy resin surface such as Hysol 13-009. This mold release capability of Teflon is useful when contamination of a resin surface cannot be tolerated. Teflon and Ram 225 (Silicone) are compared as release agents. They are about equal in terms of the force required to separate a mold from its resin casting. Teflon is superior in its resin casting cleanliness, but its film is susceptible to mechanical damage. Considering these qualities, Teflon can be a useful material, but its application must be chosen with care. (auth)

2715 METHOD TO ESTIMATE THE WATER CONTENT OF CONCRETE SHIELDS. Hilsdorf, H. K. (Univ. of Illinois, Urbana). Nucl. Eng. Design, 6: 251-63(1967).

The modes by which water may be held within concrete are described. The major parameters affecting the water content of concrete are discussed and a method is given for estimating the water content of concrete both for the case of a drying concrete and for a concrete that is in moisture equilibrium with the surrounding atmosphere. The method is applicable for structural members exposed to temperatures up to 40°C. Some data are also given for the water content of concrete at high temperatures. Means of maintaining a high water content and experimental procedures to determine the water content of concrete are described. (auth)

2716 MECHANICAL BEHAVIOR OF BERYLLIUM WIRE-REINFORCED PLASTIC COMPOSITES. Schwartz, H. S.; Mahieu, W.; Schwartz, R. T. pp A41-55 of Advanced Fibrous Reinforced Composites. Vol. 10. Azusa, Calif., Society of Aerospace Material and Process Engineers, 1966.

Unidirectional and multidirectional composites of 5-mil dia Be wire combined with an epoxy resin were fabricated and their mechanical behavior in tension, compression, flexure and shear loading modes determined. The composites possessed good bonding between the filament and matrix. Continuity in the filament and matrix phases was apparently maintained at all stress levels up to failure. In general, the composite stress-strain behavior reflected that of the Be reinforcement, with an initial linear relationship followed by decreasing stress-strain rate to failure. The yield strengths of the composites at 0.2% offset strain were 80 to 90% of the ultimate strengths. The efficiency with which the Be reinforcement modulus and strength was translated into composite properties was greater than 80%. The composites failed by plastic deformation sometimes followed by buckling (compression) or fracture (tension). Plastic deformation in a composite may be desirable as a mechanism for redistributing local stress concentrations and increasing the energy required to cause failure. The specific elastic modulus and specific ultimate strength of the Be composites were high, but their proportional limits were less than one-third of the ultimate strength. Variation of the moduli with stress above the proportional limit is an important consideration especially in connection with buckling phenomena. (Rev. Met. Lit.)

PHYSICS (GENERAL)

Astrophysics and Cosmology

Refer also to abstracts 2955, 2956, 3158, and 3528.

2717 (LA-DC-8944) SOLAR WIND OBSERVATIONS. Coon, J. H. (Los Alamos Scientific Lab., N. Mex.). [1967]. Contract W-7405-eng-36. 27p. (CONF-670825-1). Dep. CFSTI.

From Conference on Earth's Particles and Fields, Freising, Germany.

Vela-2 and Vela-3 satellite observations of the solar wind in the region of space near the Earth are summarized. The results include information on bulk velocity of the plasma, transverse temperature, temperature anisotropy, interplanetary magnetic field, flow direction, and alpha particles in the solar wind. (J.H.M.)

2718 RADIO SOURCES IN THE VICINITY OF SOURCE M 31. Varsavsky, Carlos M. (Instituto Argentino de Radioastronomia, Buenos Aires, Arecibo Ionospheric Observatory, Puerto Rico). Science, 158: 1043-5(Nov. 24, 1967).

The region α (right ascension) equal to $23^h\ 50^m$ to $01^h\ 30^m$, δ (declination) 39°20′ to 40°40′ was observed at 195 and 430 MHz with the 1000-foot (300 m) telescope of the Arecibo Ionospheric Observatory. Eighteen sources from the Ohio Catalogue and source 3C 13 are contained in this region. It is concluded that the sources have straight-line spectra with indices between −0.4 and −0.9 and that they are probably not associated with M 31, except those within the optical limit of the nebula. (auth)

2719 DIAMAGNETIC SOLAR-WIND CAVITY DISCOVERED BEHIND MOON. Colburn, D. S.; Currie, R. G.; Mihalov, J. D.; Sonett, C. P. (Ames Research Center, Moffett Field, Calif.). Science, 158: 1040-42(NOV. 24, 1967).

Preliminary Ames-magnetometer data from Explorer 35, the lunar orbiter, show no evidence of a lunar bow shock. However, an increase of the magnetic field by about 1.5 gamma (over the interplanetary value) is evident on Moon's dark side, as well as dips in field strength at the limbs. Interpretation of these spatial variations in the field as deriving from plasma diamagnetism is consistent with a plasma void on the dark side, and steady-state ($\dot{B} = 0$) magnetic transparency of Moon. (auth)

2720 ANGULAR MOMENTUM TRANSPORT IN THE SOLAR NEBULA. Starr, Victor P.; Gaut, Norman E.; Copeland, Judith A. (Massachusetts Inst. of Tech., Cambridge). Pure Appl. Geophys., 67: 221-32(1967).

It is proposed that gravitational torques can furnish a mechanism for the radial outward transport of angular momentum in the solar nebula. For this effect to be present the disc of the nebula must have a spiral structure with trailing arms. A mathematical model is constructed with the main object of seeing whether purely advective inward eddy transports of angular momentum could offset the gravitational torques. It is found that for a protosun much more massive than the disc the eddy transport is small, allowing the gravitational effects to predominate. In such a case convergence of angular momentum is to be expected at the outer edge of the disc. The possibility exists that matter could be shed to large distances perhaps giving rise to the cloud of comets surrounding the solar system as proposed by J. H. Oort. (auth)

2721 SPACE DISTRIBUTION OF IDENTIFIED QUASI-STELLAR OBJECTS AND RADIOGALAXIES. Burbidge, G. T. (Univ. of California, San Diego); Hoyle, F. Nature (London), 216: 351-2(Oct. 28, 1967).

It is stated that, independent of any optical selection effect, the number of quasi-stellar radio sources is approximately comparable with the number of radio galaxies down to a radio flux of 9 units at 178 Mc. The red shifts of the quasars extend up to about 2, where a limiting value appears to exist. The red shifts of the radio galaxies, however, extend only up to about 0.25. This means that if a cosmological interpretation of all such red shifts is accepted the quasars occupy a spatial volume about a thousand times greater than that occuppied by the radio galaxies. The approximate equality of numbers had then to be explained on the basis that the density of radio galaxies is about a thousand times greater than the density of the quasars. It then appears fortuitous that these two large factors should compensate each other. The situation appears particularly odd in view of the similarities that appear to exist between quasars and the nuclei of Seyfert galaxies, and between quasars and N-type galaxies. The cosmological interpretation of the red shifts of quasars is not supported by the form of the red shift−magnitude plot, at optical and at radio frequencies. This form is consistent with a gravitational interpretation, provided that the low-frequency radio emission is considered to arise in a more extended region than the optical emission. For sources of very small angular size there does appear to be a correlation between radio flux and red shift. All these considerations suggest that the quasars and radio galaxies are members of the same family of phenomena, and that they occupy similar volumes of space. Quasars with small red shifts could be at distances comparable with those required by a cosmological interpretation of the total red shift, but quasars of large total red shift must have shifts due to local gravitation ≈ total red shift. Quasars with small red shifts could be at distances comparable with those required by a cosmological interpretation of total red shift (z), but quasars of large z must have shifts due to local gravitation (z_g) ≈ z. A plot is reproduced of visual magnitude against z for 104 quasars. 3C 273 is an exceptional case, but can be understood if it is exceptionally close, so that $z \approx z_g$. The assumption that all quasars are intrinsically similar is unlikely to be true. It seems likely that quasars with large z_g will be intrinsically fainter than those of small z_g. This leads to the curious situation that quasars of large z_g may well be systematically closer than those of small z. This again leads to a model in which radio galaxies and quasars behave in opposite senses with regard to z. The distances of radio galaxies increase with z, whereas the opposite is true for quasars. It may be that all quasars with large red shift are comparatively close. (UK)

2722 COUNTS OF THE QUASI-STELLAR RADIO SOURCES. Nishida, Minoru; Takarada, Katsuo (Kyoto Univ.). Progr. Theor. Phys. (Kyoto), 38: 518-20(1967).

Since the work by Hoyle and Burbidge (Nature, 210: 1346(1966)) the number of the quasars whose red shifts are known has doubled. The log N−log S curve is plotted for a sample of about 70 quasars in order to test whether the conclusion drawn by H and B will hold for a sample of this size. The results indicate that Hoyle and Burbidge's conclusion may hold true. (W.D.M.)

2723 MEASUREMENT OF THE COSMIC MICROWAVE BACKGROUND AT 8.56-mm WAVELENGTH. Wilkinson, David T. (Princeton Univ., N. J.). Phys. Rev. Lett., 19: 1195-8(Nov. 13, 1967).

A technique was developed to make precision measurements of the cosmic microwave background radiation with simple Dicke radiometers. A measurement made at $\lambda = 8.56$ mm gives a radiation temperature of $2.56^{+0.17}_{-0.27}$°K, in good agreement with new results obtained at longer wavelengths. (auth)

2724 NEW MEASUREMENTS OF THE COSMIC MICROWAVE BACKGROUND AT $\lambda = 3.2$ cm AND $\lambda = 1.58$ cm-EVIDENCE IN SUPPORT OF A BLACKBODY SPECTRUM. Stokes, R. A.; Partridge, R. B.; Wilkinson, David T. (Princeton Univ., N. J.). Phys. Rev. Lett., 19: 1199-1202(Nov. 13, 1967).

In an effort to delineate the spectrum of the cosmic blackbody radiation, more accurate measurements of the intensity at wavelengths of 3.2 and 1.58 cm were made. The results, combined with those at $\lambda = 8.56$ mm, indicate that over this wavelength range the spectrum is that of a black body at $2.68^{+0.09}_{-0.11}$°K. In particular, a hot greybody spectrum does not fit the results. (auth)

2725 X-RAY EMISSION FROM Cen XR-2. Manley, Oscar P. (American Science and Engineering, Cambridge, Mass.). Contract F44620-67-C-0065. Phys. Rev. Lett., 19: 1144-5(Nov. 6, 1967).

An attempt is made to relate the possible behavior of Cen XR-2 in the visible portion of the spectrum to the reported variation of its x-ray luminosity. It is concluded that the available data on Cen XR-2 yield the following history consistent with the hot-plasma model: A dense HII cloud ($\sim 10^9$/cm^3) of radius $\sim 2 \times 10^{14}$ cm was somehow heated at a constant volume to nearly 2×10^{7}°K in a matter of a little over 1 year. Early during the heating phase it should have appeared as a blue star brighter than ~12th mag. It then preceeded to expand isothermally at the rate of about 5×10^7 cm/sec. If this sequence of events is sufficiently realistic, on extrapolating into the near future, Cen XR-2 should cease to be an observable extar within one year. (W.D.M.)

2726 TERRESTRIAL ORIGIN OF ^{26}Al AND OCEANIC SEDIMENTATION RATE. Yokoyama, Y. (Centre des Faibles Radioactivites, Gif-sur-Yvette, France). Nature (London), 216: 569-71(Nov. 11, 1967).

It was stated by Lal and Venkatavaradan (Science 151: 1381 (1966)) that the amount of ^{26}Al in marine sediments is an order of magnitude higher than expected as a result of its production

by cosmic-ray interactions in the terrestrial environment. These authors concluded that the large amount can only be explained by postulating an influx with extraterrestrial dust which has been exposed to a significant flux of energetic particles capable of producing nuclear interactions. The present author recalculated the data of Lal and Venkatavaradan in the light of new cross-section measurements, and obtained results suggesting that the large amount of ^{26}Al can, in fact, be explained by its production solely through cosmic interactions in the terrestrial atmosphere. Measurements were made of ^{10}Be and ^{26}Al activities in the surface layer of the South Pacific core, giving a ratio of ^{26}Al to ^{10}Be of 0.2 ± 0.1 in freshly deposited sediment. The formation cross section of ^{10}Be by spallation of atmospheric nuclei was found to be an order of magnitude lower than indicated previously. Rates of sedimentation were re-evaluated both by the ^{10}Be method and the ^{26}Al method. From the ^{10}Be data a value of about 0.3 mm/1,000 yr was found in South and North Pacific cores. From the ^{26}Al data the rate was found to be about 0.2 mm/1,000 yr. Results are compared with those obtained by the ionium/thorium and other methods. (UK)

2727 CHEMICAL FRACTIONATIONS IN METEORITES. II. ABUNDANCE PATTERNS AND THEIR INTERPRETATION. Larimer, John W.; Anders, Edward (Univ. of Chicago). Geochim. Cosmochim. Acta, 31: 1239-70(Aug. 1967).

Abundances of thirty-one volatile elements in meteorites are reviewed. In carbonaceous chondrites of Types I, II, and III and enstatite chondrites of Type I, abundances decrease by constant factors, in ratios of 1/0.6/0.3/0.7. In ordinary chondrites and Type II enstatite chondrites, nine elements (Au, Cu, F, Ga, Ge, S, Sb, Se, and Sn) likewise are depleted by constant factors of ~0.25 and ~0.5, while eighteen others (Ag, Bi, Br, C, Cd, Cl, Cs, H, Hg, I, In, Kr, N, Pb, Te, Tl, Xe, and Zn) show more drastic depletions, to factors of 0.002. Apparently chondrites are a mixture of two types of material: a low-temperature fraction (matrix) that retained most of its volatiles, and a high-temperature fraction (chondrules, metal grains) that lost them. Evidence is presented that these fractionations occurred in the solar nebula as it cooled from high temperatures. The fractionations cannot have been produced in the meteorite parent bodies. The following accretion temperatures are inferred from the abundance patterns: carbonaceous chondrites, ≤400°K; Type I enstatite chondrites, 400 to 480°K; ordinary and Type II enstatite chondrites, 530 to 650°K; unequilibrated ordinary chondrites, ≤530°K. These temperatures are much higher than the present black-body temperature in the asteroid belt, 170°K. They could, however, have been reached during collapse of the solar nebula or the high-luminosity, pre-main-sequence stage of the protosun. This model also accounts for the presence of organic compounds and primordial noble gases in meteorites, the extreme depletion of Pb, Bi, Tl, and In in ordinary chondrites, and the low alkali content of the earth and carbonaceous chondrites. The following tentative distance assignments are given: enstatite chondrites come from the inner fringe of the asteroid belt; ordinary chondrites from the center and inner half; carbonaceous chondrites form the outer fringe or come from comets. (auth) (UK)

2728 ENERGY EMISSION FROM A NEUTRON STAR. Pacini, F. (Cornell Univ., N. Y.). Nature (London), 216: 567-8(Nov. 11, 1967).

In a newly formed neutron star, apart from its thermal energy content, which is dissipated very fast because of neutrino processes, there will also be much energy stored in vibrational and rotational form. The problem arises of ascertaining whether the stored energy plays an important part in connection with the activity observed in some supernova remnants, such as the Crab Nebula. The vibrations of a neutron star disappear very quickly; hence it would seem rewarding to look for mechanisms by which the star can release either its magnetic or rotational energy, or both. A possible model ("oblique rotator") for such release is discussed. The existence of very strong magnetic fields in neutron stars has been suggested as a consequence of compression of an ordinary stellar field; fields of 10^{10} to 10^{14} gauss can be produced in this way. Stresses and MHD waves may be expected at the star surface. Energy will be dissipated, with the final result of bringing the system into an equilibrium state. Acceleration of particles to relativistic energies is also to be expected. Another possibility is that a neutron star might directly emit electromagnetic waves of very low frequency. Once these waves are emitted and propagated in the supernova remnant they will be reflected by the circumstellar gas if the plasma frequency exceeds the radiation frequency, and by this means a large amount of energy and momentum could be pumped from the neutron star into the supernova remnant. The radiation will give an outward momentum to the nebula, by being reflected, and therefore accelerate its expansion. There is observational evidence that the motion of the Crab Nebula has been accelerated after the original explosion. Generation of high energy electrons can be expected in the region where the electromagnetic waves are reflected, and can cause rapid compression of the nebular gas. It will be of importance to evaluate the emission of gravitational waves from the star. (UK)

2729 STUDIES OF SHORTWAVE SOLAR RADIATION IN THE USSR. Mandelshtam, S. L. (Lebedev Inst. of Physics, Moscow). Appl. Opt., 6: 1834-44(Nov. 1967).

A history is presented of measurements of solar vacuum uv and soft x radiation made by rocket and satellite-borne instruments in the U.S.S.R. The origin and mechanism of the production of solar x rays are discussed. (auth)

2730 EVOLUTION OF STARS OF LOW MASS. Ezer, Dilhan (Goddard Space Flight Center, New York); Cameron, A. G. W. Can. J. Phys., 45: 3461-77(Nov. 1967).

Evolutionary sequences of models in the early and main sequence stages were constructed for stars in the mass range $0.1\underline{M}_\odot$ to $0.4\underline{M}_\odot$ with a composition $X = 0.739$, $Z = 0.021$. The general behavior of the evolutionary track in the Hertzsprung–Russell diagram is similar to that obtained for medium-mass stars. The $0.4\underline{M}_\odot$ star reaches the main sequence in 4×10^8 years, with a radiative core covering about half of the mass. The $0.3\underline{M}_\odot$ star develops a radiative core before reaching the main sequence in 8.5×10^8 years, but with the onset of thermonuclear reactions the energy generation is strong enough to cause the central radiative region of this star to become convective again. The $0.2\underline{M}_\odot$ star reaches the main sequence as a wholly convective star in 1.7×10^9 years. During the evolution of the $0.1\underline{M}_\odot$ star, the maximum central temperature attained is 4×10^6°K, which is not sufficient to stabilize the star on the hydrogen-burning main sequence. Therefore, as contraction continues, the star contracts towards the white dwarf configuration. (auth)

2731 EARLY AND MAIN-SEQUENCE EVOLUTION OF STARS IN THE RANGE 0.5 TO 100 SOLAR MASSES. Ezer, Dilhan (Goddard Space Flight Center, New York); Cameron, A. G. W. Can. J. Phys., 45: 3429-60(Nov. 1967).

The evolutionary study previously carried out for the sun was extended to stars of 0.5, 0.7, 2, 5, 10, 20, 50, and 100 solar masses. The evolutionary calculations were started at the threshold of energy stability, carried through the approach to the main sequence, and (with the exception of the 100 solar-mass model) through the depletion of hydrogen on the main sequence. All models were observed to have a completely convective Hayashi phase. There was general agreement, in the appropriate mass range, with the evolutionary studies of Iben, the discrepancies apparently resulting from different opacities used in the calculations. Lines of equal evolutionary age in a Hertzsprung–Russell diagram constructed from these calculations do not agree with the observations of Walker, probably because of the neglect of mass loss and rotation in the early stellar evolutionary histories. (auth)

2732 IMBEDDING OF A MODEL OF THE UNIVERSE WITH MAGNETIC FIELD IN PSEUDO-EUCLIDIAN SPACE. II. Smaranda, D. (Faculte de Mathematique et Mecanique, Bucharest); Navez, J. Bull. Soc. Roy. Sci. Liege, 36: 185-92(1967). (In French).

The semi-closed magnetic model of the Universe is considered. In a previous paper, a necessary and sufficient condition for the space of being of class one was established, together with the immersion formula. It is observed that these formulae are available only if $\dot{X} \neq 0$. In the case $\dot{X} = 0$, the space is of class one for any Y(t) and the immersion formulae are given. (auth)

2733 MODIFIED WEIGHT FUNCTION THEORY FOR THE CALCULATION OF THE FRAUNHOFER LINES IN THE SUN AND STAR SPECTRA. Gussmann, E. A. (Astrophysikalisches Observatorium, Potsdam, Ger.). Monatsber. Deut. Akad. Wiss. Berlin, 9: 149-56(1967). (In German).

The weight function theory introduced by Unsöld for the calculation of the Fraunhofer lines and its modification are compared. An example is given of the use of the modified weight function theory. (J.S.R.)

2734 GENERATION OF HEAVY NUCLEI ON THE SUN. Suslov, A. A.; Tindo, I. P. Kosm. Issled., 5: 617-21(July-Aug. 1967). (In Russian).

The increase in the flux of heavy nuclei ($Z \gg 15$) in cosmic radiation, measured February 23–24, 1964 by the Electron-2 sputnik, is described. Simultaneously, an increase in the x radiation of the Sun was detected with Geiger counters on the sputnik. A significant increase in the flux of nuclei with $Z \gg 2$, $Z \gg 5$, and proton components was not observed. The probability of a change coincidence

of the increase of the nuclear flux and the x rays was evaluated as 1.5×10^{-5}. This leads to the hypothesis of a generation of the nuclei on the Sun with conclusions on the boundary of the solar atmosphere of principally heavy nuclei and electron bremsstrahlung. (tr-auth)

2735 IMBEDDING OF THE OPEN MAGNETIC MODEL OF THE UNIVERSE IN PSEUDO-EUCLIDIAN SPACE. Navez, J. (Institut de Mathematique, Liege). Bull. Soc. Roy. Sci. Liege, 36: 211-28(1967). (In French).

In previous papers the imbedding of the semi-closed magnetic model of the Universe was studied. In this paper, the imbedding of the open magnetic model of Universe for any X(t) and Y(t) is discussed. The necessary and sufficient condition for the space of being of class one is found and it is observed that the imbedding formulae and the signature of the pseudo-Euclidean space S_3 in which the model is imbedded are different when $\dot{Y}^2 > 1$ or $\dot{Y}^2 < 1$. When $\dot{Y}^2 = 1$ and $X = 0$, the class of the space is always zero. (auth)

2736 STABLE AND UNSTABLE MODES IN THE SOLAR CORONA. Winterberg, F.; McLellan IV, A. (Univ. of Nevada, Reno). Nuovo Cim. (10), 51B: 557-61(Oct. 11, 1967).

Plasma wave propagation was investigated within a magnetized atmosphere under the influence of gravity in the MHD approximation, which is valid for low-frequency waves. The propagation of these waves in a magnetized atmosphere is considered and dissipative effects arising from viscosity, electric resistivity, and heat conductivity are neglected. (W.D.M.)

2737 MAXWELL EQUATIONS AND HUBBLE EFFECT. Rosen, N. (Israel Inst. of Tech., Haifa). Nuovo Cim. (10), 51B: 568-9(Oct. 11, 1967).

This note is related to two earlier papers, (Ann. Phys. (N. Y.), 35: 426(1965) and 42: 334(1967), dealing with the behavior of physical systems in an expanding universe. It is shown that the field equations of electromagnetic theory for the case of a homogeneous isotropic expanding Universe lead to the Hubble red shift. (W.D.M.)

2738 SHOCK WAVES AT HIGH DENSITIES. II. Masani, A.; Ferrari, A.; Martini, A. (Univ., Turin). Nuovo Cim. (10), 51B: 257-75(Oct. 11, 1967).

The study of shock waves propagating through plasmas in such critical physical conditions as can be of interest in astrophysical problems is continued. In part I the case of very high temperatures was studied. In Part II, densities $\lesssim 10^{10}$ g cm^{-3} are analyzed. Interest is extended only up to 10^{15} g cm^{-3}, because for higher densities the presence of nuclear forces introduces many difficulties (not yet completely resolved) in the formulation of a general-state equation. Between these two limits is found the range of densities that are likely to be present in the interiors of neutron stars and supernovae. The shock characteristics are calculated (for one-dimensional stationary shocks) for the above range of densities modifying the Rankine–Hugoniot conditions and the state equation of the medium to take into account nucleonic degeneracy, pair creation, radiation, transformation of chemical composition following the beta-equilibrium reactions, and so on. It is found that weak shock waves can easily take off the plasma nucleonic degeneracy. But strong shock waves ($z = P_2/P_1 > 10^4$) characterized by very high propagation velocities ($v \simeq c$) must occur in order to increase the temperature up to 10^{9}°K; these cases are treated relativistically. Finally, tables and graphs of the results obtained are given. Astrophysical applications are only outlined; they will be treated elsewhere. (auth)

2739 RELATIVISTIC COSMOLOGY. Rindler, Wolfgang (Southwest Center for Advanced Studies, Dallas). Phys. Today, 20: No. 11, 23-31(Nov. 1967).

A general review on relativistic cosmology is presented in terms of the problems, the tools, cosmological principle, Robertson–Walker model, cosmological horizons, red shift, narrowing the model, difficulties, the age problem, steady-state theory, dynamics for cosmology, pseudo-Newtonian theory, general relativity, pressure, Friedman-equation solutions, observational evidence, and the Robertson diagram. (W.D.M.)

2740 CONTINUUM RADIATION FROM QUASI-STELLAR SOURCES. Jukes, J. D. (United Kingdom Atomic Energy Authority, Abingdon, Eng.). Nature (London), 216: 461(Nov. 4, 1967).

Although the mechanism of synchrotron radiation from relativistic electrons in a magnetic field provides a valid explanation of the continuum electromagnetic radiation from extended cosmic sources, such as radio galaxies, it meets with serious difficulties in respect to the nuclei of quasars. Assuming that quasars are at cosmological distances it is found that their internal radiation field is so intense that it causes overwhelming loss of fast electrons by inverse Compton scattering. Also a strong magnetic field reduces the lifetime of the fast electrons unacceptably. It is shown in this communication that these difficulties are overcome simply if it is assumed that relativistic protons are responsible for the bulk of the synchrotron radiation, particularly at its maximum in the millimetre and infra-red wavelengths, just beyond the limit usually set by self-absorption. For simplicity the relativistic protons are assumed to be monoenergetic, although no great difficulty arises in assuming a more plausible power law energy spectrum. As an example the quasar 3C 273B is considered. It is concluded that the quasar source nucleus is a small object with radius about 1 light-day, well within the limits imposed by observed short period intensity fluctuations. The magnetic field is strong, but the total magnetic energy is still very small compared with a radio galaxy. (UK)

2741 FISSION AND SPALLATION XENON IN METEORITES. Clark, R. S.; Rao, M. N.; Kuroda, P. K. (Univ. of Arkansas, Fayetteville). J. Geophys. Res., 72: 5143-8(Oct. 15, 1967).

Xenon isotope abundance data from other investigations were analyzed with the aid of an IBM 7040 computer to determine by a least-squares method the best values for the isotope ratios of the fission and spallation xenon. The isotope ratios of Murray were used as the trapped or primordial component. The values obtained were: fission component (normalized to ^{136}Xe = 1.00) ^{131}Xe = 0.38, ^{132}Xe = 1.05, and ^{134}Xe = 0.95; spallation or cosmogenic component (normalized to ^{130}Xe = 1.00) ^{124}Xe = 0.64, ^{126}Xe = 1.07, ^{128}Xe = 1.53, ^{131}Xe = 3.73, and ^{132}Xe = 0.62. (auth)

2742 COSMOGENIC RADIOACTIVITIES IN THE PEACE RIVER AND HARLETON CHONDRITES. Shedlovsky, Julian P.; Cressy, Philip J. Jr.; Kohman, Truman P. (Carnegie Inst. of Tech., Pittsburgh). J. Geophys. Res., 72: 5051-8(Oct. 15, 1967).

The results of measurements of cosmogenic radionuclides in the Peace River and Harleton chondrites shortly after their falls are reported. Activity ratios of short- and long-lived nuclides are compared with ratios observed in other freshly fallen meteorites. Long-term temporal constancy of the cosmic-ray flux within 50% is supported, and a spatial variation of cosmic radiation of less than a factor of 2 throughout meteoritic orbits is indicated. The 11-year solar cycle does not appear to have had any significant effect on activities with halflives of the order of about a year, such as ^{54}Mn and ^{22}Na, except for ^{60}Co in Harleton, which seems to be high in our specimen as a result of solar-particle effects. The activities are compared with thick-target production cross sections. (auth)

2743 GRAVITATIONAL COLLAPSE. Thorne, Kip S. Sci. Amer., 217: No. 5, 88-92; 95-8(Nov. 1967).

The history of catastrophic gravitational collapse of a body is followed and the collapse of the universe is discussed. The principal events that theory predicts should take place when a star collapses through its gravitational radius are described. (W.D.M.)

2744 CORONA IN THE SOLAR ECLIPSE OF MAY 20, 1966. Waldmeier, M. (Eidgenoessische Sternwarte, Zurich). Z. Astrophys., 67: 169-84(1967). (In German).

On the occasion of the annular, almost total solar eclipse of May 20, 1966, pictures of the inner corona were obtained. Immediately before central eclipse the western part of the corona was photographed by occulting the solar crescent at the east limb; after central eclipse the eastern part was photographed by masking the solar crescent at the western limb. By this method only the equatorial regions could be observed. The brightness distribution in these regions is given. Corresponding to the large N–S asymmetry in photospheric and chromospheric activity the northern corona is by far more luminous than the southern. The temperatures and the densities too are higher in the northern hemisphere. The x-ray image, the radioheliogram, and the optical picture of the corona are very similar. The coronal condensations appear more pronounced in x rays and radio waves than in the visual light, because the former emissions are proportional to N_e^2, whereas the white light intensity is proportional to N_e. Not only is the density increased in the condensations but also the inhomogeneity. (auth)

2745 DISTRIBUTION OF SPIRAL ARM POPULATION IN THE NEIGHBORHOOD OF THE SUN. Richter, G. M. (Institut fuer Relativistische und Extragalaktische Physik, Potsdam, Ger.). Z. Astrophys., 67: 185-92(1967). (In German).

In order to test various types of objects as spiral arm tracers and to find the positions and directions of the arms, an objective method is proposed. Bright cepheids are shown to be unsuitable as spiral arm tracers. The concept of logarithmic spirals on which the method is based is shown to be useful. The pitch-angle between spiral arm and radius vector is found to be ~54°; angles ≥70° can be excluded. (auth)

2746 STRUCTURE OF THE OUTER ATMOSPHERE OF THE SUN AND OF COOL STARS. Ulmschneider, Peter (Univ., Wuerzburg, Ger.). Z. Astrophys., 67: 193-218(1967).

Models of the transition layer and lower corona of the Sun and stars of type K1 III, G3 III, and G7 V are computed using an improved shock dissipation theory and taking into account the detailed energy balance of shock dissipation and conduction versus flow energy and radiative losses. In the transition layer very steep temperature gradients are obtained since conduction has to balance radiative losses. Comparison with observations yields good agreement. General conclusions concerning coronal temperatures, temperature gradients, radiative and mass fluxes of cool stars are presented. (auth)

2747 BOLOMETRIC CORRECTIONS FOR CENTRAL STARS OF PLANETARY NEBULAE. Boehm, K. H. (Lehrstuhl fuer Theoretische Astrophysik, Heidelberg). Z. Astrophys., 67: 219-21(1967). (In German).

Bolometric corrections were determined for 9 nongrey model atmospheres of central stars of planetary nebulae. These bolometric corrections are always larger than those for black body radiation of the same effective temperature. The deviation is almost constant in the range $6.3 \times 10^{4\circ}K \leq T_{eff} \leq 1.5 \times 10^{5\circ}K$. It practically disappears at $1.8 \times 10^{5\circ}K$. (auth)

2748 ACCURACY OF FIRST ORDER PERTURBATION THEORY FOR UNIFORMLY ROTATING POLYTROPES. Monaghan, J. J. (Cambridge Univ., Eng.). Z. Astrophys., 67: 222-6(1967).

It is shown that the first-order perturbation theory for uniformly rotating polytropes is as accurate as the Monaghan–Roxburgh method. The large errors in previous determinations of the surface are shown to arise from an incorrect form of the boundary condition on the density. (auth)

2749 INTERACTION BETWEEN CONVECTION AND PULSATION IN δ CEPHEI STARS. Kamijo, F. (Tokyo Univ.). Z. Astrophys., 67: 227-42(1967). (In German).

The interaction of the convection with the pulsation in δ Cephei stars is numerically studied with the help of Unno's theory in a detailed model ($M = 7\ M_\odot$, $\log L/L_\odot = 3.663$, $\log T_e = 3.728$) lying on the evolutionary track of a $7\ M_\odot$ star. The instability coefficient turns out to be 2.7 times as large as that calculated by Baker and Kippenhahn (1965). An analytical study making use of Baker's one-zone approximation confirms that this large instability is a result of pulsation–convection coupling, especially in the upper layers. (auth)

2750 PHOTOGRAPHIC OBSERVATIONS OF 3C 273. Zwicky, F.; Karpowicz, Maria; Rudnicki, K. (Carnegie Institution of Washington, Washington, D. C. California Inst. of Tech., Pasadena). Z. Astrophys., 67: 243-5(1967).

Photographic observations of 3C 273 for the period from 1934 to 1961 are presented. (auth)

2751 AN RR LYRAE VARIABLE PROJECTED ON THE ANDROMEDA NEBULA. Moffat, A. F. J. (Ruhr-Univ. Bochum, Bonn); van den Bergh, Sidney. Z. Astrophys., 67: 246-8(1967).

An RR Lyrae star with $\langle V \rangle = 16.88$ and a period of 0.5788 days has been found projected on a spiral arm of M31. Photoelectrical photometry of this variable, which is located at a distance of 19 kpc, should be capable of providing accurate information on reddening of the Andromeda Nebula. (auth)

2752 BRIGHTNESS VARIATIONS AND PROPER MOTION OF THE X-RAY SOURCE SCO X-1. Klare, Gerhard (Landessternwarte, Heidelberg). Z. Astrophys., 67: 249-52(1967). (In German).

Photographic magnitudes for the variable star, which has been identified with the x-ray source Sco X-1, were estimated on 14 plates earlier than 1954. The annual proper motion was found to be $\mu = 0\overset{''}{.}038$. The estimated distance seems to be less than 1000 pc. (auth)

2753 SOLAR WIND AND PLANETARY ROTATION. Alfonso-Faus, Antonio (Univ. of Minnesota, Minneapolis). J. Geophys. Res., 72: 5499-5501(Nov. 1, 1967).

It is shown that a body orbiting the sun and immersed in the solar wind acquires angular momentum with respect to the axis perpendicular to the orbital plane, through the body's center of mass, and of the same sense as the orbital motion around the sun. The mechanism is discussed in relation to the planets in an attempt to account for their present angular velocity around their axes. (auth)

2754 EFFECT OF THE SUN'S ROTATION ON THE SOLAR WIND. Alfonso-Faus, Antonio (Univ. of Minnesota, Minneapolis). J. Geophys. Res., 72: 5576-7(Nov. 1, 1967).

The effect of the Sun's rotation on the solar wind has been treated recently by Modisette (1967), Weber and Davis (1967), and Alfonso-Faus (1967), with similar results in their major features. Two subjects treated in the previous work (Alfonso–Faus) that are not covered by Modisette or Weber and Davis are presented. The subjects are nonradial flow near the Sun and flow out of the solar equatorial plane. (J.H.M.)

2755 POSSIBLE EXISTENCE OF A 29-DAY PERIOD IN THE SUNSPOT NUMBER SERIES 1940-1964. Toman, K. (Air Force Cambridge Research Labs., Bedford, Mass.). J. Geophys. Res., 72: 5570-1(Nov. 1, 1967).

A spectrum is shown from earlier work (Toman, 1966) by applying the Fourier transform method to the sunspot number series Z (1940–1964). The spectrum is analyzed, and details of the spectrum in the vicinity of 27 days are illustrated. (J.H.M.)

2756 THE EFFECT OF THE FILAMENTARY INTERPLANETARY MAGNETIC FIELD STRUCTURE ON THE SOLAR FLARE EVENT OF MAY 4, 1960. Bukata, R. P.; Palmeira, R. A. R. (Southwest Center for Advanced Studies, Dallas). J. Geophys. Res., 72: 5563-8(Nov. 1, 1967).

Studies of solar flare effects conducted by means of a worldwide network of neutron monitors and meson telescopes have verified the general Archimedes spiral configuration of the solar magnetic field advanced by Parker. The extremely short-lived May 4, 1960, solar flare effect was a well-documented event with extensive coverage by neutron monitors and meson telescopes. A review is given of some of this coverage, indicating the percentage enhancements above background recorded by the various detectors. An attempt is made to show that the observations of the event may be satisfactorily explained in terms of a filamentary configuration of the interplanetary field, and that the time profile of the event, as witnessed by ground-based instrumentation, was a logical consequence of the nature of the filamentary structure at the time of particle injection. (J.H.M.)

2757 EAST–WEST STRUCTURE OF RADIO SOURCES AT 1425 MHz. Fomalont, Edward Berel. Pasadena, Calif., California Inst. of Tech., 1967. 287p.

Thesis.

The east–west radio structures of 532 sources were obtained with the Cal Tech variable-spacing interferometer at a frequency of 1425 MHz. The visibility function, measured at nine interferometer spacings between 144λ and 2626λ, are presented in tabular form for all of the sources. The east–west source structures were calculated by a model fit of the data or by a direct numerical inversion of the data. The statistics of the radio structures were analyzed. There are three major structure types: simple double, halo-core, and triple. The simple double sources have two distinct components of emission having nearly equal intensities and diameters with the radio galaxy lying at the center of the two components in most cases. The halo-core sources consist of a small radio core, usually complex, coincident with the radio galaxy and a much larger region of emission, the halo, not necessarily symmetrically disposed around the radio core. The triple and more complex sources are discussed briefly and it is suggested that many are genetically related to double and halo-core sources. Other results from the observations are: a slight correlation of the radio and optical structure of galaxies; a difference for the N–S relation of quasars and radio galaxies based on their statistical separation by brightness temperature; a model for the evolution of a double source in which the component separation increases at five times the rate of the expansion of the component diameters; the lack of simple sources characterized by one main region of emission; and the suggestion that 3C 120 and 3C 236 are involved in a violent explosion. (Disser. Abstr.)

2758 EXTENSION ON NONTHERMAL RADIO SOURCE SPECTRA TO 8000 Mc. Dent, William Albert. Ann Arbor, Univ. of Michigan, 1966. 140p.

Thesis.

The flux densities of 35 nonthermal radio sources were measured at a frequency of 8000 Mc (λ 3.75 cm). There are no previously reported flux densities for most of these sources above 3200 Mc. The antenna temperatures of the sources were measured by two independent procedures. Corrections were made for the finite angular size of the source, the variation of the antenna gain with its orientation, the linear polarization of the source, receiver response nonlinearities, and atmospheric extinction. The flux density calibration was made relative to absolute measurements of Cas A, Tau A and Cyg A by other observers. The radio source spectra extended to 8000 Mc are presented using the lower-frequency flux density measurements in the survey of Conway, Kellermann, and Long (1963). (TSS) (Disser. Abstr.)

2759 ELECTRON DENSITIES IN H II REGIONS FROM OBSERVATIONS AT 4 CM. Cunningham, Ashley Anthony. Berkeley, Calif., Univ. of California, 1966. 54p.

Thesis.

Observations of NGC 6523, NGC 6611, NGC 7000, and IC 410 were made with the University of California 85-foot radio telescope, at a wavelength of 4 cm. Using spherical models, one-dimensional electron density distributions were computed at an electron temperature of 8000°K. From the density profiles, the ages of these diffuse nebulae were estimated. These ages are considerably shorter than the element-burning lifetimes of the exciting stars. (Disser. Abstr.)

2760 ATMOSPHERIC DYNAMICS IN A MODEL RR LYRAE STAR. Castor, John Irvin. Pasadena, Calif., California Inst. of Tech., 1967. 180p.

Thesis.

A dynamical model of an RR Lyrae star was constructed which is similar to those of Christy in its treatment of the envelope interior to the hydrogen ionization zone but which describes the hydrogen ionization zone and the outer atmosphere in some detail. In the optically thin region heat transfer is described with the gray equation of radiation transfer which yields an integral expression for the heating rate, assuming small deviations from sphericity. (TSS) (Disser. Abstr.)

2761 INFLUENCE OF MASS LOSS ON THE EVOLUTION OF A RED GIANT STAR OF 5 SOLAR MASSES. Forbes, Jack Eugene. Berkeley, Calif., Univ. of California, 1966. 97p.

Thesis.

A method is described for computing the evolution of a stellar model subject to the ejection of matter from the surface. The method has been so devised that any existing stellar-evolution computing program for the more usual case of constant mass can easily be adapted for use in the case of variable stellar mass. Neither theoretical work done thus far nor the observational data permit the calculation of the rate of mass loss with any certainty, and an ad hoc assumption has therefore been made that the rate is proportional to the mass in the outer convective zone, or envelope. This is in qualitative agreement with observation in that rate of loss is observed to be highest in red giants with the lowest surface temperatures, which also happen to be those for which the mass in the convective envelope is greatest. Two evolutionary sequences, II and III, are computed with original masses five times that of the Sun, and with different values of the proportionality factor between the envelope mass and the rate of loss, III having the greater value. These sequences are compared with another sequence, I, having a constant mass of five solar units. The initial compositions are the same and correspond approximately to population I. The evolution of these models is followed until the central helium is exhausted, the helium-burning shell source has become established, and the erstwhile hydrogen-burning shell source has become inert owing to a drop in temperature. The central regions now consist chiefly of oxygen, and there is a possibility that the oxygen-burning phase will follow. The calculations are not pursued into that phase, because neutrino energy losses have not been allowed for, and they may become important during later stages. It is found that the time scale of evolution is changed surprisingly by loss of mass. No significant differences in the evolutionary tracks appear until the masses of II and III have been reduced to 1.65 and 0.96 solar units. Thereafter, as the Salpeter 3α helium-burning reaction becomes a prominent energy source, the effective temperature increases to a maximum value in each case. The mass loss in II and III terminates automatically when the models enter evolutionary phases in which the envelope disappears. At this time their masses have been reduced respectively to 1.026 and 0.915 solar units. II remains rather similar to I, though at one point about a magnitude fainter, in spite of the great reduction in its mass. III, on the other hand, though reduced in mass only slightly below II, shows a radically changed behavior and reaches a much higher effective temperature. It is fainter than II at this point, but still greatly overluminous for its mass. The results are of interest in connection with the visual binary γ Leonis, whose components appear to be less massive than the mass–luminosity relation would predict from the absolute magnitudes. Also, an attempt by Christy to fit a theoretical calculation of pulsation to the characteristics of the classical cepheid variables δ Cephei and η Aquilae suggests that these stars also may be undermassive for their luminosities. (Disser. Abstr.)

2762 DYNAMICAL EFFECTS OF ISOTROPIC RADIATION. Savickas, David Francis. East Lansing, Michigan State Univ., 1966. 67p.

Thesis.

A small spherical body traveling through an isotropic radiation field will generally experience a force caused by the momentum it absorbs from the radiation. Due to the Doppler shift, the radiation striking the front of the particle will be of higher frequency than the radiation striking the back of the particle. Also, because of diffraction effects, a small particle will absorb amounts of momentum that differ with the radiation's wavelength. These two factors generally combine to exert a force on the particle and change its velocity. The effect of this force on the particle's motion was investigated. By the use of relativistic mechanics a general expression for the force on the particle due to a plane-parallel beam of radiation was obtained and then integrated over space to obtain the total force of the whole radiation field. The diffraction effects were taken into account by use of either Debye's approximations for the pressure efficiency factors of very small particles, or by the use of graphs of this factor as a function of frequency. For approximations at low velocities it was found that the ratio of the initial velocity at a later time is independent of the initial velocity. Generally the radiation exerts a retarding force on the motion of the particle. However, for special cases where an essentially monochromatic and isotropic field exists, it was found that the particle could be accelerated to higher velocities by the radiation. Numerical estimates for the time it would take a particle in interstellar space to come to $1/e$ its initial velocity were found to be of the order of from 10^{10} to 10^{11} years. (Disser. Abstr.)

2763 VELOCITY FIELDS IN SUNSPOTS: THE EVERSHED EFFECT. Alder, Stephen Miller. Ann Arbor, Mich., Univ. of Michigan, 1966. 148p.

Thesis.

Four spots were studied in detail, using photometric sections (line profiles) constructed with the isophotometer at the McMath–Hulbert Observatory. Asymmetries, which are presumably caused by a motion of material in the spots, are seen in the penumbral profiles. The profiles were analyzed first using the assumption of a gradient of velocity with depth and later assuming that the asymmetries are the result of a high-velocity stream. An attempt was made to distinguish between these two hypotheses by using solar lines of two different excitations, Fe I 5576 and Ba II 6497, anticipating that they are formed at different depths in the solar atmosphere. However, for the particular location of the spots on the solar disk, the two lines (as studied in their respective spots) are formed at approximately the same depth in the atmosphere. A correction for the limb effect, which is the apparent shift of a solar line toward the red as the limb of the Sun is approached, is also considered. This correction is necessary only if the limb effect occurs in the photosphere and not in the spot. The reduction procedure, which assumes that the velocity field is radially symmetric about the center of the spot, allows the determination of both the direction of flow and its magnitude. It is found that the maximum flow velocities are similar for the spots studied. Typical velocities are 1.7 km/sec with the velocity-gradient hypothesis and 7.4 km/sec with the high-velocity stream hypothesis. No apparent correlations are found between the flow velocities for different spots and the area, magnetic field, activity, or age of the spots, but, statistically, the sample is rather small. If a correction for the limb effect is applied, the direction of flow is very similar to the direction of the lines of force of the penumbral magnetic field as found by Leroy (1962). (Disser. Abstr.)

2764 STUDY OF TWO TOPICS IN GENERAL RELATIVITY: THE COSMOLOGICAL RED SHIFT AND GRAVITATIONAL WAVES. Ludwig, Garry. Providence, Brown Univ., 1966. 92p.

Thesis.

Two different topics in general relativity were investigated. The first topic deals with the cosmological red shift. The red-shift formula is rederived by two alternative methods that give new insight into how this frequency shift arises. The second topic deals with the generation of gravitational waves. Westervelt's result for the radiated gravitational flux due to the emission and absorption of electromagnetic waves is obtained in a more general form from a "scalar" expression for the gravitational flux. Defining a so-called "ideal oscillator" and using it as a model for a crystal, Weber's conclusion concerning the gravitational power radiated from a crystal driven off resonance is shown to contain two errors. First, this power depends primarily on the dielectric properties of the crystal, not as Weber claims, on its piezoelectric properties. Secondly, Weber appears to have neglected radiation from the generator driving the crystal off resonance. (Disser. Abstr.)

2765 OBSERVATIONAL STUDY OF THE HYDRODYNAMICS OF THE LOWER SOLAR PHOTOSPHERE. Frazier, Edward Nelson. Berkeley, Calif., Univ. of California, 1966. 117p.

Thesis.

Vertical oscillations with a period of approximately 300 seconds have been observed in the solar atmosphere for several years. This study is an observational investigation of these oscillations in the region of the lower solar photosphere, and of the relation of these oscillations with the underlying convection zone. The observations consisted of a series of high resolution, high dispersion spectrograms taken at the McMath Solar Telescope at Kitt Peak National Observatory. The spectrograms showed the small scale

Doppler shifts and intensity fluctuations that are caused by the oscillatory and convective motions. Three absorption lines were chosen for study: Si II λ6371.36, Fe λ6364.38, and Fe λ6355.04. The Si II line is a weak, highly excited line (E. P. = 8085 e.v.), and is formed at an average depth of $\tau_0 \approx 1$. Thus it is expected to be formed in the convection zone itself. The other two lines are formed at intermediate depths extending up to the temperature minimum of the photosphere. (TSS) (Disser. Abstr.)

2766 STRUCTURE AND EVOLUTION OF LOW-MASS STARS. Graboske, Harold Conrad Jr. Ann Arbor, Mich., Univ. of Michigan, 1966. 251p.

Thesis.

The structure and evolution of low-mass stars are investigated to determine the dominant physical factors which govern their evolution. The major physical problem is the accurate evaluation of the thermodynamic properties of moderately dense stellar gases, where electrostatic interaction between the charged particles composing the gas modify its thermodynamic behavior. The importance of this and other physical effects is evaluated by constructing evolutionary models of 0.1 $M_\odot$ and 0.05 $M_\odot$ stars. (TSS) (Disser. Abstr.)

2767 LOCAL NEUTRAL HYDROGEN GAS AND ITS RELATIONSHIP TO GOULD'S BELT. Hansen, Henry Kimball. Berkeley, Calif., Univ. of California, 1966. 99p.

Thesis.

A series of 21-cm observations was made at the Hat Creek Radio Astronomy Observatory of the University of California in order to study the general distribution of neutral hydrogen in the Galaxy and the possible correlation of this distribution with Gould's Belt of Bright Stars. The observations consist of drift curves taken across the galactic plane and out to 30° galactic latitude while using a receiver bandwidth of 1 MHz. The hydrogen distribution that is observed shows a strong concentration toward the galactic plane, but there is also considerable hydrogen present at high latitudes. The general features of the hydrogen distribution show a correlation with the distributions of dark material and bright diffuse nebulae that are observed in the Galaxy. But the correlation with Gould's Belt is not unambiguous. The galactic ridgeline observed in the integrated hydrogen distribution falls very close to the mean galactic plane in the central regions of the Galaxy; but in other parts of the galactic circle the ridgeline departs from the plane by as much as four degrees, and in one area it shows two distinct branches. The spiral structure of the Galaxy is evident in the peaks which are observed in the integrated hydrogen density along the ridgeline. Two inner arms are apparent as is the one containing the Sun. Two equiangular spirals fitted to these peaks have a torsion angle of about 83°. To study the radial distribution of neutral hydrogen in the Galaxy, a model consisting of concentric rings of varying densities was constructed which reproduces the observed integrated densities along the ridgeline. This model indicates that approximately 70% of all the neutral hydrogen in the Galaxy is located farther from the galactic center than the Sun is, whereas the galactic center itself is a region of relatively low neutral hydrogen density. The model yields a density of 0.4 H atom/cm^3 in the solar vicinity and permits a maximum of about 0.15 H atom/cm^3 in the central region of the Galaxy. Investigation of the effects of absorption indicate that in the direction of the galactic center the observed hydrogen line emission has been reduced about 24% by absorption. The observed hydrogen densities throughout the region studied were compared with the densities predicted by a uniformly stratified model. Several relatively nearby clouds of hydrogen show up as areas of "excess" hydrogen in this comparison, and it appears that the Sun is located in a region of about average hydrogen density with several denser clouds located in the surrounding regions within about 200 parsecs. (Disser. Abstr.)

2768 TRIPLET SPECTRUM OF NEUTRAL HELIUM IN PLANETARY NEBULAE. Robbins, Ralph Robert Jr. Berkeley, Calif., Univ. of California, 1966. 170p.

Thesis.

The object of the investigation was to calculate the emissions of the triplet states of neutral helium for various gaseous configurations approximating actual planetaries. In the first part, the equations of radiative capture and subsequent cascade are formulated for the triplet states, and a solution is effected which takes explicitly into account all energy levels up to n = 20 and estimates accurately the contribution of higher levels. Also, cross sections specifying the redistribution of electrons within the higher quantum levels by collisions are estimated and incorporated through a reformulation of the equations of statistical equilibrium. Thus the populations of the states and relative intensities in the various recombinations series are obtained as a function of both the electron temperature and density. Results are obtained for temperatures of 10,000 and 20,000°K and for densities ranging from 500 to 10^7 electrons/cm^3. Although the effects due to collisions are not dramatic, a number of observable lines are found to be weak indicators of electron density. In the second part, the calculated line intensity ratios are modified to allow for the self-absorption effects arising from the metastability of the 2^3S level. The configurations treated are spheres of constant electron density and temperature and having a uniform distribution of helium atoms in the 2^3S level. The spheres are also considered to be expanding with a constant velocity gradient. An integral equation of transfer is derived and solved numerically, giving the number of absorptions in each member of the principal series and the number of conversions to other emission series. Thus relative intensities are derived for a series of optical depths and expansion rates. The relative efficiency and accuracy of various numerical approaches to the transfer equation are also discussed. In the calculations, the assumptions of complete redistribution and "exact" redistribution are tested as a function of both optical depth and rate of expansion. An additional complication in the transfer problem is the presence of a strong hydrogen line H8 blended with an important helium line 2^3S-3^3P at 3889 Å. The effect of this interaction is tested as a function of optical depth. It is found that to produce a given change in the line intensity ratios requires a much greater optical depth than previous calculations had indicated. This effect is particularly dramatic when the expansion of the nebula is incorporated. Optical depths found from the present work exhibit much better agreement with expected optical depths in planetary nebulae. (Disser. Abstr.)

2769 EDDY TRANSPORT MAINTENANCE OF SOLAR DIFFERENTIAL ROTATION. Nickel, George Herman. Davis, Calif., Univ. of California, 1966. 62p.

Thesis.

The differential rotation of the Sun is interpreted as the largest axisymmetric mode of two-dimensional surface turbulence which is symmetric under reflection through the equatorial plane. The amplitude of this mode is determined by a balance of energy transport into the mode from smaller modes and energy dissipation by eddy viscosity. These smaller modes could be either photospheric turbulence or larger-scale motions due to a horizontal instability which could arise if the solar equator were slightly warmer than the poles. Energy transport to large modes from small modes is a property of two-dimensional turbulence; an estimate is made for the maximum radial velocity of large scale motions in the convective zone for which the model is valid. A computer mode of the nonlinear interaction of these two-dimensional modes verifies that energy can be transported to the differential rotation mode, and that the correlation of zonal and meridional velocities is in qualitative agreement with results obtained from sunspot observations. (Disser. Abstr.)

2770 PREDICTED ULTRAVIOLET RADIATION FROM STELLAR CHROMOSPHERES. Patterson, Normal Paul. New Haven, Yale Univ., 1966. 94p.

Thesis.

The flux emitted in the Lyman continuum and Lyman-α line from a plane-parallel, stationary, hydrogen atmosphere is computed by an iterative method. Results are given for several assumed temperature and density variations which were chosen to include the range of conditions possible in the outer atmospheres of stars with hydrogen convection zones and chromospheric activity. The hydrogen atom is approximated by two bound levels and a continuum. A frequency-independent, line source function is used. All line profiles show a central depression and narrow peaks. The solar model adopted gives flux values and a line profile in good agreement with observations. The results suggest that stellar emission in Lyman α is observable and that important information about the structure of the outer stellar atmosphere could be inferred from such an observation. (Disser. Abstr.)

2771 PHOTOMETRIC STUDY OF REFLECTION NEBULAE Roark, Terry Paul. Troy, N. Y., Rensselaer Polytechnic Inst., 1966. 147p.

Thesis.

The purpose of the investigation was to determine the physical properties of the scattering particles which constitute reflection nebulae. Both the theoretical and observational facets of the problem are explored. Theoretical models are constructed for plane-parallel slabs of scattering material. The light incident on the elemental scattering volume is assumed to be scattered only once. However, this single scattering model is modified by including the physical extinction of the incident and scattered light as it traverses the nebula. Exact Mie theory is used to calculate the scattering cross sections for graphite, iron, and dielectric spheres. The models thus constructed yield predicted nebular colors, on the UBV system, as a function of offset distance from the source of illumination. It is shown that no single physical or geometrical parameter will characterize any given color relation between the

model and the star. The Maia, Merope, and Alcyone nebulae in the Pleiades and NGC 7023 have been observed photoelectrically. The differences in both (B−V) and (U−B) colors between the illuminating star and points on the nebula were obtained. The "instrumental" scattered light was determined and used to correct the observed nebular colors. This correction is found to be very important at small offset distances. A comparison between the observed nebular colors and those predicted by the models indicates that the scattering particles in the nebulae do not behave as predicted for lossy spheres. The observations are consistent however with dielectric scattering particles having mean sizes slightly larger than those yielding the "standard" interstellar reddening law. (Disser. Abstr.)

2772 LOW-LUMINOSITY MEMBERS OF THE HYADES CLUSTER. van Altena, William Foster. Berkeley, Calif., Univ. of California, 1966. 82p.

Thesis.

Proper motions, visual magnitudes, and B−V colors were determined for 778 stars in the Hyades region. The probability of membership in the Hyades cluster, based on proper motions only, was derived for each star. The radial distribution of bright Hyades members is much larger than that for faint members. The cluster mass necessary to support the observed tidal radius of 25 pc (for the bright stars is larger by a factor of 200 than the estimated maximum mass of about 350 $M_\odot$. The color−magnitude diagram for probable Hyades members shows a main sequence and a well-populated subdwarf sequence. There is evidence for membership of some subdwarfs in the Hyades cluster. The luminosity function for cluster members is found to increase as far as $M_V \simeq +13$ and then to decrease essentially to zero $M_V \simeq +15-16$. (Disser. Abstr.)

2773 MOON AND PLANETS. A Session of the Seventh International Space Science Symposium, Vienna, 10–18, May 1966. Dollfus, A. (ed.). Amsterdam, North-Holland Publishing Co., 1967. 331p. $12.60; Hfl. 45.-. (CONF-660570).

Twenty-seven papers on various aspects of the moon and planets are presented. Principal topic areas are: lunar surface, planets in general, planet Mars, and theoretical problems. (J.H.M.)

2774 ADVANCES IN THE ASTRONAUTICAL SCIENCES. VOLUME 19. UNMANNED EXPLORATION OF THE SOLAR SYSTEM. Proceedings of the American Astronautical Society Symposium, February 8–10, 1965, Denver, Colorado. Morgenthaler, George W.; Morra, Robert G. (eds.). Advan. Astron. Sci., 19: 1-979(1965). (CONF-650224).

This volume contains the following major addresses presented at the Symposium: "The Promise of Solar System Exploration", "A Review of Biological Material in Meteorites", "The Military Value of Space Exploration", and "Spadework for Exploration of the Solar System". Papers are also included under the following principal topic areas: solar probe objectives; interplanetary space, comets, and asteroids; observations and deductions about planets; planetary atmospheres; life sciences objectives in solar system exploration; design of fundamental life sciences probe experiments; probe instrumentation and electronics; deep space communications; probe trajectory guidance and navigation; spacecraft design considerations; and launch vehicles. (J.H.M.)

2775 ZODIACAL LIGHT AND INTERPLANETARY DUST. Gillett, Frederick Carl. Minneapolis, Univ. of Minnesota, 1966. 135p.

Thesis.

Balloon observations of the brightness and polarization of the zodiacal light from above 100,000 ft are reported. It is shown that there is a nearly unique model for the distribution of interplanetary dust which will account for these observations and the observations of the outer F corona. The number density of zodiacal dust is given by, $n(a,r)da = 4 \times 10^{-12}(r/D)^{-\frac{1}{2}}\,(a/a_0)^{-3}\,da$; $a_0 = 0.25\mu$ where (r/D) is the distance from the Sun in AU and a is the particle radius in microns. The distribution of ecliptic inclinations of the zodiacal dust is very nearly that of the observed asteroids. It is shown that the asteroid belt could easily sustain the zodiacal cloud for the lifetime of the solar system and that collisions in the asteroid belt can supply enough small particles. This model predicts a loss mechanism in addition to the Poynting−Robertson effect and the necessary loss rate is in excellent agreement with the expected rate of sputtering by solar wind particles. The solar wind is shown to exert less drag on the zodiacal dust particles than solar radiation under "quiet" conditions, and although it may exceed the radiation drag during solar storms, the duration of such storms is too short to significantly affect the zodiacal dust. (Disser. Abstr.)

Atomic and Molecular Physics

Refer also to abstracts 3315, 3362, and 3663.

2776 (DESY-67/27) ABSORPTION MEASUREMENTS OF COPPER, SILVER, TIN, GOLD, AND BISMUTH IN THE FAR ULTRAVIOLET. Haensel, R.; Kunz, C.; Sasaki, T.; Sonntag, B. (Deutsches Elektronen-Synchrotron, Hamburg (West Germany)). Aug. 1967. 23p. Dep.

Absorption measurements on copper, silver, tin, gold, and bismuth in the spectral range 50 to 340 Å were performed using the synchrotron radiation of the 6-GeV synchrotron DESY. The results are compared with previous measurements and theoretical predictions. A calculation of the partial oscillator sums from the available data gives rough agreement with the theoretically expected values. (auth)

2777 (LA-3725) THEORY OF A RADIOFREQUENCY "SPIN FILTER" FOR A METASTABLE HYDROGEN, DEUTERIUM, OR TRITIUM ATOMIC BEAM. Ohlsen, Gerald G.; McKibben, Joseph L. (Los Alamos Scientific Lab., N. Mex.). July 1967. 58p. Dep. CFSTI.

Techniques for selection of metastable hydrogen, deuterium, or tritium atoms with a particular nuclear spin polarization are discussed. The emphasis is on the three-level interaction technique, which promises to be the most versatile and satisfactory of those available. (auth)

2778 (NYO-3661-5) EFFECT OF MINOR IMPURITIES IN CRYSTALLINE ANTHRACENE AND BENZENE ON POSITRON ANNIHILATION. Tao, S. J.; Lee, John (New England Inst. for Medical Research, Ridgefield, Conn.). Nov. 1967. Contract AT(30-1)-3661. 14p. (CONF-670414-5). Dep. CFSTI.

From Meeting of the American Physical Society, Washington, D. C.

Positron annihilation in anthracene of different purities at room temperature and benzene of different purities at temperatures near its melting point was investigated using the lifetime technique. No long lifetime component can be separated from the annihilation spectra for positrons in zone-refined anthracene of either single-crystal or powder form. However, a definite long lifetime component of about 1.3 nsec and intensity about 2% exists in the lifetime spectra for positrons in anthracene samples of either blue−violet fluorescence grade or highest-purity grade. From the result of a 2-component exponential analysis the values of annihilation rates λ_1 and λ_2 and intensity I_2 for benzene samples of purer quality, e.g., spectra-analyzed grade, show sharper discontinuities near the melting point than benzene sample of lower quality, e.g., common certified A.C.S. grade, in their plots against temperatures. A 3-component exponential analysis of the lifetime spectrum showed that at temperatures below the melting point the annihilation lifetime curves for benzene samples of the higher purity fit a 2-component scheme better than a 3-component one. However, for benzene samples of less purity at same temperatures the curves fit a 3-component scheme better than the 2-component. This indicates that the disorder in crystalline structures of anthracene and benzene due to the presence of minor amount of impurities plays an influential role in positron annihilation process in solids. (auth)

2779 (NYO-3661-11) COMPUTATION OF TIME DEPENDENT POSITRON ANNIHILATION RATE. Tao, S. J. (New England Inst. for Medical Research, Ridgefield, Conn.). Nov. 1967. Contract AT(30-1)-3661. 16p. Dep. CFSTI.

The methods of computation of time-dependent positron annihilation rate from the known values of annihilation and scattering cross sections or rates are described. A part of the work, the case of continuous slowing down, was carried out. The work on the case of inelastic scattering is waiting to be attacked. It is assumed that the reader is familiar with the technique of positron annihilation. (auth)

2780 (UCRL-Trans-10134) TABLES OF PHOTOIONIZATION CROSS-SECTIONS OF THE HYDROGEN ATOM. Volkov, B. I.; Grechukhin, D. P.; Karpushkina, E. I. (Gosudarstvennyi Komitet po Ispol'zovaiyu Atomnoi Energii SSSR, Moscow. Institut Atomnoi Energii). Translated by T. Watt for Univ. of California Lawrence Radiation Lab., Livermore, from report IAE-873. 252p. Dep. CFSTI. JCL $16,50 fs, $7,76 mf.

An abstract of the original report in Russian appeared in NSA as abstract 20: 17251. (A.G.W.)

2781 PERIODIC ELECTROSTATIC FOCUSING OF BEAMS OF ELLIPTIC CROSS SECTION. Syrovoi, V. A. Zh. Prikl. Mekh. Tekh. Fiz., No. 2, 127-9(Mar.-Apr. 1967). (In Russian).

This is a continuation of earlier work (Zh. Prikl. Mekh. Tekh. Fiz., No. 4(1965)) where an exact analytic solution was presented of the problem of shaping a ribbon beam with nonmonotonic variation of the potential on the boundary. In the present article, the author derives a simple analytic solution of the problem of shaping

beams with elliptic cross section, based on approximating the potential on the boundary by means of a quadratic parabola. This makes it possible to investigate geometries which have larger eccentricities than in the earlier investigation, and can serve as a model for taking into account the edge effects in ribbon beams of finite width. The problem consists of solving the appropriate boundary-value condition in series form and approximating the accuracy. It is indicated that the difference between the approximate solution and the exact one is of the same order as in the earlier investigation, especially in the region where the curvature of the beam boundary is small. (ATD)

2782 ELECTRON-IMPACT EXCITATION OF THE 2S STATE AND AUTOIONIZATION BELOW THE n = 3 LEVEL OF He^+ (EXPERIMENTAL). Daly, N. R.; Powell, R. E. (Atomic Weapons Research Establishment, Aldermaston, Eng.). Phys. Rev. Lett., 19: 1165-7(Nov. 13, 1967).

A study was made to determine the shape of the excitation function for $He^+ + e \rightarrow He^+(2S)$ very close to threshold and to look for resonance effects in this reaction. (M.O.W.)

2783 CLOSE-COUPLING CALCULATIONS OF ELECTRON-IMPACT EXCITATION OF THE 2S STATE AND AUTOIONIZATION BELOW THE n = 3 LEVEL IN He^+. Ormonde, Stephan (Lockheed Palo Alto Research Lab., Calif.); Whitaker, William; Lipsky, Lester. Contract AF 29(601)-6801. Phys. Rev. Lett., 19: 1161-5 (Nov. 13, 1967).

Electron scattering on He^+ between 42 and 52 eV was investigated. The main results reported are (a) the first calculations and classifications of autoionizing levels in helium between the n = 2 and n = 3 thresholds of He^+ which agree with experimental observations; (b) a possible explanation of the peak in Q(1s−2s); and (c) a prediction of the detailed shape of Q(1s−2s) between n = 2 and n = 3 thresholds. (M.O.W.)

2784 BEAM STUDIES OF ENERGY DEPENDENCE OF HOT-ATOM REACTIONS. Menzinger, Michael; Wolfgang, Richard. (Yale University, New Haven. J. Amer. Chem. Soc., 89: 5992-3 (Nov. 8, 1967).

The reactions of hot tritium atoms above threshold were explored by beam experiments. The monoenergetic tritium ions in the energy range 1 to 200 eV were bombarded with 50-eV electrons. The ions were extracted, accelerated to 200 eV, focused by a series of electrostatic lenses, and mass analyzed by a simple Wien filter. After deceleration to the desired energy by a 12-element expontential lens, the beam was impinged on a liquid-nitrogen chilled target of solid cyclohexane. The target was volatilized and analyzed for tritiated products by radio gas chromatography. Results showed that yield increased with energy, the yield of cyclohexane-t from a high-energy T^+ beam was within experimental error of that from hot atoms produced by nuclear recoil, and the shape of the yield function was, after appropriate normalization, similar for initial T_3^+ and T^+ beams. (D.H.M.)

2785 CALCULATION OF STOPPING POWER OF A HEAVY CHARGED PARTICLE IN MATTER. Turner, J. E. (Oak Ridge National Lab., Tenn.). Contract W-7405-eng-26. Health Phys., 13: 1255-63(Dec. 1967). (ORNL-P-2890).

The basic problem of calculating the linear rate of energy loss (stopping power) of an energetic heavy charged particle is reviewed. The calculations of stopping power by Bohr and by Bethe are treated in some detail. The assumptions underlying Bethe's quantum mechanical stopping power formula and their modifications leading to shell corrections and the density effect are discussed. A few brief statements about the calculation of stopping power by means of the Thomas−Fermi model of the atom are included. Some unsolved problems concerned with charged particle penetration are discussed. (auth) (UK)

2786 QUANTUM DEFECT THEORY. V. AUTOIONIZING AND BOUND STATES OF THE NEUTRAL BERYLLIUM ATOM. Moores, D. L. (London Univ.). Proc. Phys. Soc. (London), 91: 830-41(Aug. 1967).

Positions and widths of six series of autoionizing states 2pnl of the neutral beryllium atom are calculated (i) by direct solution of 2s−2p close-coupling equations for the system $Be^+ + e^-$ in the elastic scattering region, and (ii) by solving the same equations above the 2p excitation threshold and using the many-channel quantum defect theory to extrapolate below threshold. Results of the two methods are compared. By extrapolation below the 2s threshold, the positions of the bound states of the neutral atom are calculated allowing for configuration mixing. (auth) (UK)

2787 INTERACTION POTENTIALS OF H AND He ATOMS AND H_2 MOLECULES. Belyaev, Yu. N.; Leonas, V. B. (Moscow State Univ.). Dokl. Akad. Nauk SSSR, 173: 306-8(Mar. 11, 1967). (In Russian).

Information about short-range interaction potentials of H and He atoms, and of H_2 molecules is important because it gives a basis for calculating kinetic properties of gases containing these components. The potential function for H_2-H_2 and $H-H_2$ in the interaction range of 0.25 to 2.5 eV is the basis for computing the hydrogen transfer coefficient at 2500 to 25,000°K. The present paper investigates the dependence of the effective cross section of elastic scattering upon energy at 600 to 4,000 eV in H−He, $H-H_2$, He−He, $He-H_2$, and H_2-H_2 systems, as plotted in a graph. A formula is developed for small-angle scattering with a spherically symmetric interaction potential, and then proved experimentally with detectors producing resolution on the order of 2×10^{-3}. A table compares potentials and scatter ranges for the four systems. (ATD)

2788 THE DEVELOPMENT OF SOVIET OPTICS AND SPECTROSCOPY DURING THE PAST FIFTY YEARS. Frish, S. Appl. Opt., 6: 1783-92(Nov. 1967).

A history of Soviet spectroscopy is given, with special emphasis on various areas indicating the earliest workers in each specialty and their principal successors; for example, the work of Rozhdestvenskii (anomalous dispersion), Fok (self-consistent field calculations), Terenin (photochemistry, atomic beams), Mandelshtam (combination scattering), Vavilov (luminescence, quantum properties of light), Cherenkov (radiation), Chaika (atomic lifetimes), Gross (excitons), and Volkenstein (molecular vibrations). (auth)

2789 EFFECT OF RESONANT CHARGE EXCHANGE COLLISIONS ON UNIPOLAR ION STREAMS. Sajben, Miklos (California Inst. of Tech., Pasadena). Phys. Fluids, 10: 2383-8(Nov. 1967).

The effect of resonant charge exchange collisions between an initially monoenergetic unipolar ion stream and a uniform neutral background gas is investigated by postulating simplified collision mechanism. First-order approximation to the velocity distribution function for distances small compared to the mean free path and an asymptotic distribution function for large distances are obtained; both are found to be highly anisotropic. The results are valid if the ion energy gained between subsequent collisions is large compared with the thermal energy of the neutral gas. Errors introduced by the physical assumptions are discussed. (auth)

2790 ON DYNAMIC POLARIZABILITY, COUPLED AND UNCOUPLED APPROXIMATION FOR MANY OPEN SHELLS. Malinowski, S. (Univ. of Lodz, Poland). Acta Phys. Pol., 32: 479-83(1967).

The coupled and uncoupled approximations used to describe the effects for many open shells of electronic systems by means of time-independent perturbation are discussed. (auth)

2791 APPROXIMATIONS IN THE THEORY OF TWO-QUANTUM PHOTO-DETACHMENT OF NEGATIVE IONS. Corinaldesi, E. (Boston Univ.); Kang, Ik-Ju. Nuovo Cim. (10), 51B: 550-4(Oct. 11, 1967).

The meaning and implications of the plane-wave approximation used by Geltman (Phys. Lett., 4, 168 (1963) and 616 (1965)) are discussed for the process $h\nu + h\nu + I^- \rightarrow I + e$, where I^- is a negative iodine ion. The ratio between the amplitude for this process and that for the one-photon reaction $2h\nu + I^- \rightarrow I + e$ is considered. (J.F.P.)

2792 THEORETICAL SLATER INTEGRALS FOR THE GROUND STATE OF XENON III. Foglia, C. (Univ., Parma, Italy). Phys. Lett., 25A: 650-1(Nov. 6, 1967).

Values of Slater parameters, spin−spin and spin−orbit parameters, and other quantities related to atomic wave functions for Xe III in its ground state configuration are reported. (auth)

2793 PERTURBATION TREATMENT OF THE MANY-ELECTRON PROBLEM. Jankowski, K. (N. Copernicus Univ., Torun, Poland). Acta Phys. Pol., 32: 421-6(1967).

A perturbation treatment of the many-electron problem is proposed, which starts from the poleless eigenvalue equation of Hirschfelder instead of from the Schrödinger equation. Preliminary, encouraging numerical results for the ground state of the helium atom are presented. (auth)

2794 PHOTOELECTRON DIFFUSION IN A STRONG MAGNETIC FIELD. Elesin, V. F.; Bykovskii, Yu. A. (Moscow Engineering Physics Inst.). JETP Lett. (USSR) (Engl. Transl.), 6: 29-31(July 15, 1967).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu, 6: 497-500(July 15, 1967).

It is shown that in strong magnetic fields ($\Omega\tau_{op} \gg 1$, Ω = Larmor frequency) high-energy photoelectrons can play a predominant role in the diffusion current, and this leads in turn to special singulari-

ties of the photocurrent, in particular, a change in the sign of the Kikoin–Noskov photoelectromagnetic effect (PEM). (W.D.M.)

2795 DIFFERENTIAL COLLISION CROSS SECTIONS OF ARGON AND NEON. Penta, J.; Mueller, C. R.; Williams, W.; Olson, R.; Chakraborti, P. (Purdue Univ., Lafayette, Ind.). Phys. Lett., 25A: 658-9(Nov. 6, 1967).

The elastic differential collision cross sections of argon with itself and neon with itself have been measured using the modulated beam technique with mass spectrometric detection. (auth)

2796 APPROXIMATE METHOD OF CALCULATION OF CHARGED-PARTICLE INTENSIVE CURVILINEAR BEAMS. Mikheev, N. I.; Chuyan, R. K.; Bryukhnov, P. M. Radiotekh. Elektron., 642-9(Apr. 1967). (In Russian).

Approximate solutions for the intrinsic problem of intense curvilinear particle beam trajectories coinciding with the family of coordinate lines of an arbitrary orthogonal curvilinear coordinate system are found. The system of differential equations describing the beam parameters is reduced to a single nonlinear ordinary differential equation of the second order as a function of the parameter. The solution of the equation at various boundary conditions, reflecting various physical particle motion conditions are analyzed. The delay of a curvilinear plane-parallel charged particle beam is calculated. (tr-auth)

2797 INTENSITY DISTRIBUTION IN THE ROTATIONAL AND VIBRATIONAL STRUCTURE OF N_2^+ BANDS DUE TO THE PASSAGE OF H_2^+ IONS THROUGH A NITROGEN–HELIUM MIXTURE. Polyakova, G. N.; Fogel, Ya. M. Opt. Spectrosc. (USSR) (Engl. Transl.), 22: 538-9(June 1967).

Translated from Opt. Spektrosk., 22: 988-90(June 1967).

An increase in the intensity of the $I_{gr}N_2^+$ bands was observed upon comparison of the emission due to the passage of H_2^+ ions of 25 keV through N_2 at a pressure of 5×10^{-4} mm Hg and through a N_2 + He mixture (pressure of added He 8×10^{-3} mm Hg). (W.D.M.)

2798 LINE SHAPE OF THE SPONTANEOUS EMISSION OF AN ATOM IN THE CASE OF IMPERFECT INTERMIXING OF DEGENERATE LEVELS. Morozov, V. A. Opt. Spectrosc. (USSR) (Engl. Transl.), 22: 526-7(June 1967).

Translated from Opt. Spektrosk., 22: 971-3(June 1967).

It is shown that the spontaneous-emission line shape of an atom depends, in the case of incomplete intermixing of its excitation states, on which of the states the atom assumes upon excitation. It is also shown which excitation method causes the line to split and which excitation method results in the line having one maximum. (W.D.M.)

2799 CALCULATION OF THE BINDING ENERGY OF INNER ATOMIC ELECTRONS IN THE GENERALIZED WKB APPROXIMATION. Zhirnov, N. I. Opt. Spectrosc. (USSR) (Engl. Transl.), 22: 469-70(June 1967).

Translated from Opt. Spektrosk., 22: 857-60(June 1967).

The accuracy of the generalized WKB method when used to calculate the binding energy of inner electrons in multielectron atoms is discussed. The validity of the use of this method for states with small quantum numbers is justified. (auth)

2800 INELASTIC TRANSITIONS BETWEEN THE FINE-STRUCTURE COMPONENTS OF ALKALI-METAL ATOMS IN THE CASE OF ADIABATIC COLLISIONS. II. CALCULATIONS OF CROSS SECTIONS. Dashevskaya, E. I.; Nikitin, E. E. Opt. Spectrosc. (USSR) (Engl. Transl.), 22: 473-6(June 1967).

Translated from Opt. Spektrosk., 22: 866-71(June 1967).

Cross sections are calculated for transitions between fine-structure components of excited alkali-metal atoms upon collision with atoms of inert gases. The theory explains the change in cross section, amounting to 6 to 8 orders of magnitude, at a temperature T = 360°K, on going from Na to Cs, and also the dependence of the cross section on the properties of the inert gas. (auth)

2801 ESTIMATING CROSS SECTIONS FOR IONIZATION IN SLOW-ATOM COLLISIONS. Soshnikov, V. N.; Trekhov, E. S. Opt. Spectrosc. (USSR) (Engl. Transl.), 22: 476-8(June 1967).

Translated from Opt. Spektrosk., 22: 872-5(June 1967).

A procedure is discussed for calculating the cross section $\sigma(T)$ for ionization in slow-atom collisions. In particular, the possibility of using the so-called δ function method (modified Franck–Condon principle) is noted. It is shown that there are several errors in Podlubnyi's calculations of $\sigma(t)$ for the reaction $N + O \rightarrow NO^+ + e$. For practical calculation it is necessary first of all to have exact data on the positions of the potential curves corresponding to the dissociating molecule, and to take account of the excitation of different vibrational levels of the molecular ion produced. (auth)

2802 EXCITATION TIME OF THE $B^3\pi_g$ STATE OF N_2 AT HIGH TEMPERATURES. Losev, S. A.; Smekhov, G. D. Opt. Spectrosc. (USSR) (Engl. Transl.), 22: 484-8(June 1967).

Translated from Opt. Spektrosk., 22: 889-91(June 1967).

Experimental results are described which lead to certain estimates of the excitation time of the $B^3\pi_g$ state of the N_2 molecule at temperatures from 8000 to 9000°K. The experiments were made in a stainless-steel shock tube. The radiation intensity of the bands of the first positive system of the nitrogen molecule ($B^3\pi_g \rightarrow A^3\Sigma_u^+$) was registered. To separate sufficiently narrow sections of the spectrum, a high-transmission ir monochromator was used. (M.H.R.)

2803 CALCULATION OF THE YIELD OF A VERY SIMPLE ION SOURCE OF THE OPEN TYPE EMPLOYING LONGITUDINAL IONIZATION. Slobodenyuk, G. I. Zh. Tekh. Fiz., 37: 1540-2 (Aug. 1967). (In Russian).

The energy distribution and current in the ion beam from a simple ion source consisting of a plane hot cathode, a plane anode with an opening to permit passage of electrons, and a plane aperture diaphragm with an opening to permit passage of the ions produced by ionization of the residual gas were calculated. For the calculation it is assumed that the probability for ionization by electron impact is proportional to $(U - U_i) \exp[(U - U_i)/(U_0 - U_i)]$, where U is the incident electron energy, U_i is the ionization energy of the molecules, and U_0 is the incident electron energy for maximum ionization probability. Multiple collisions and the effect on the ion energy distribution of space charge in the ionizing region are neglected. Formulas are given for the ion current and the ion energy distribution in terms of the electrode potentials, the emission current, the anode–diaphragm distance, the diaphragm aperture area, the electron mean free path, the parameters in the expression adopted for the ionization probability, and the pressure and temperature of the residual gas. There is also given a formula for the optimum cathode potential for maximum ion current. (ATD)

2804 EXPERIMENTAL STUDY OF SHORT-RANGE FORCES AND THRESHOLD IONIZATION IN ATOMIC COLLISIONS. Leonas, V. B.; Sermyagin, A. V. (Moscow State Univ.). Zh. Tekh. Fiz., 37: 1547-9(Aug. 1967). (In Russian).

Small-angle (0^0 16′ to 4^0) elastic and inelastic scattering of 4 keV He, Ne, Ar, and Kr atoms and N_2 molecules on like atoms and molecules was investigated. The elastic scattering potential was derived from the scattering data by the method of O. B. Firsov (ZhETF, 24, 279, 1953), and from this there was obtained the relation between the distance r of closest approach and the scattering angle θ. The relation between the probability P for ionization and r was then derived from the inelastic scattering data on the assumption that the relation between r and θ is the same for inelastic as for elastic scattering. The ionization probability increased rapidly (less rapidly for N_2 than for the noble gases) as r decreased below a threshold value and exhibited structure as r decreased further. This structure was clearly resolved in the case of Kr–Kr scattering and was unresolved but evident in the case of N_2–N_2 and He–He scattering. The structure of the P versus r curves is discussed briefly; it is ascribed to intersection of terms of the initial state, when the system consists of two atoms, with terms of the final state, when the system consists of an atom and an ion. It is concluded that difficulties encountered in the investigation of low energy scattering can be overcome by investigating the small angle scattering of fast atoms. (ATD)

2805 INTERACTION OF TWO RADIAL ELECTRON STREAMS. Korotun, L. I. (Inst. of Radiophysics and Electronics, Kharkov). Zh. Tekh. Fiz., 37: 1452-7(Aug. 1967). (In Russian).

The interaction of two streams of electrons moving radially in the same region with different velocities is described. The problem is treated as one-dimensional: all quantities are assumed to be independent of the azimuthal and axial coordinates Θ and z of a cylindrical coordinate system r, Θ, z, and the electron velocities (including the perturbed velocities) are assumed to have no axial or azimuthal components. The electron streams are assumed to occupy the region $r > a$, the surface $r = a$ being an electron source or sink. From Poisson's equation and the equations of motion and continuity for the two electron streams there is derived a fourth order differential equation for the amplitude of small harmonic perturbations of the velocities and densities in the two streams as a function of r. This equation is solved by a method involving contour integration in the complex plane with a Laplace kernel, and the solution is employed to discuss the behavior and interaction of radial density waves in the two interpenetrating streams. Conditions are derived for exponential increase or decrease

of the amplitude of the waves with increasing r, and formulas are given for the phase velocities of the waves. It is found that the phase velocities do not depend strongly on the perturbation frequency or the densities of the interacting electron streams; this circumstance should facilitate the design of broad band input and output devices for amplifiers employing interacting radial electron streams. (ATD)

2806 BREMSSTRAHLUNG EFFECT ON RELATIVISTIC ELECTRONS IN A STRONG RADIATION FIELD. Denisov, M. M.; Fedorov, M. V. (Lebedev Inst. of Physics, Moscow). Zh. Eksp. Teor. Fiz., 53: 1340-8(Oct. 1967). (In Russian).

Stimulated bremsstrahlung due to scattering of relativistic electrons on ions in the presence of a monochromatic electromagnetic wave is studied. The case of strong laser radiation is considered. Under certain assumptions, expressions are obtained for the integral cross sections for stimulated emission by several photons. The asymptotic case of a very strong field is considered. Expressions are obtained for the differential cross section of the process integrated over the directions of propagation of the scattered electrons. (auth)

2807 IONIZATION IN ATOMIC COLLISIONS. Smirnov, B. M. Zh. Eksp. Teor. Fiz., 53: 1400-10(Oct. 1967). (In Russian).

Ionization processes in atomic and ionic collisions are considered. The collision of two helium atoms is investigated. It is shown that for helium atoms whose electron configuration at large distances between the nuclei corresponds to two atoms in the ground state, the configuration for sufficiently small distances between the atoms corresponds to an autoionization state of a quasi molecule. The distance between the nuclei for which the electron term of the He_2 quasi molecule composed of atoms in the ground state pseudointersects the nearest electron term is estimated. The amount by which the terms are moved apart at the point of pseudointersection is also estimated. The degree of excitation of the electron shell of the colliding atoms irreversibly occurring as a result of movement of the nuclei at the moment of overlapping of the atomic electron shells is determined. It is concluded that when two helium atoms in the ground state collide, ionization occurs when the atoms fly apart since the transitions occur to He_2 quasi molecule states. For infinite distance between the nuclei these stars correspond to two atoms in the excited state and hence they become autoionizational for sufficient distances between the atoms. Decay of these autoionization states leads to liberation of the electrons. The spectrum of electrons liberated in single and multiple ionizations is elucidated on the basis of the autoionization mechanism of ionization of the colliding atoms. (auth)

2808 ON THE REDUCED-MASS CORRECTIONS TO THE FINE STRUCTURE OF π-MESIC ATOMS. Ciafaloni, M. (Scuola Normale Superiore, Pisa, Italy. Istituto Nazionale di Fisica Nucleare, Pisa, Italy). Nuovo Cim. (10), 52A: 274-85(Nov. 1, 1967).

The problem of mass corrections to the fine structure formula is examined for a spin 0−spin ½ atom with arbitrary masses of the bound particles. An approximate, purely electrodynamic, Bethe−Salpeter equation is discussed in this case, and from it a three-dimensional equation is derived which gives correctly all terms of order α^2 ryd in the binding energy. It is found that, except for S waves, the reduced mass fine structure formula is exactly true for the spinless particle, while for the spin-½ particle it is modified by terms of second order in the mass ratio. (auth)

2809 A STUDY OF THE L- AND K-AUGER SPECTRA OF ^{113}In FROM ^{113}Sn. Krisciokaitis, Raymond J.; Haynes, Sherwood K. (Michigan State Univ., East Lansing). Nucl. Phys., A104: 466-80 (1967).

The L- and K-Auger spectra for ^{113}In derived from the orbital capture decay for ^{113}Sn were measured by means of an iron-free, $\pi\sqrt{2}$ beta spectrometer. A total of 47 L-Auger lines and groups of lines were identified and their intensities estimated. Incremental nuclear charge values $\Delta Z = 0.55$ and 0.67 were found to fit the transitions of type $L_{1,2,3}-M_{1,2,3}M_{1,2,3}$ and $L_{1,2,3}-M_{4,5}M_{4,5}$, respectively. Analysis of the K-Auger spectrum led to identification of nine lines in the K−LL group, as predicted by the intermediate coupling theory. The relative intensities of the K−LL lines indicate closest agreement with calculations by Asaad who takes into account configuration interaction as well as intermediate coupling. The ratios $(K-LX)/(K-LL) = 0.431 \pm 0.003$ and $(K-XY)/(K-LL) = 0.0513 \pm 0.0007$ were also measured. (auth)

2810 AUGER TRANSITIONS AND THE SHAPE OF THE X-RAY SPECTRUM. Vedrinskii, R. V.; Kolesnikov, V. V. (Rostov-on-the-Don State Univ., USSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 31: 891-7(June 1967). (In Russian).

The authors employ the formal theory of scattering of Lippmann and Schwinger (Phys. Rev., 79: 469(1950)) and Gell-Manp and Goldberger (Phys. Rev., 91: 398(1953)) and the resonance perturbation theory of Dirac to treat the absorption of an x-ray photon by an atom as an inelastic scattering process (as a (γ,e) or a $(\gamma,\gamma e)$ process) rather than, as is usually done, as two separate processes consisting of absorption of the photon with excitation of the atom to a stationary state followed by an independent Auger transition. The calculation is performed for the definite case when the principal intermediate state has a hole in the 1s shell and the final state (in case there is only a radiative transition and no Auger transition) has a hole in the 2p shell. Changes in the self-consistent field due to radiative and Auger transitions are neglected and it is assumed that the states of the outer electrons do not change. The final formula differs from the usual one mainly in that the summation over intermediate states is performed in the calculation of the matrix element, rather than after the matrix elements have been calculated (a summation over cross sections), and therefore affords the possibility of interference. Most of the terms in the summation drop out because of the conservation laws, but interference can be appreciable if the atom has states close to the principal intermediate state. When interference occurs the line shape depends on the direction of emission of the secondary photon. (ATD)

2811 RELATIVE PROBABILITIES OF NONRADIATIVE AND RADIATIVE TRANSITIONS IN MULTIPLY IONIZED ATOMS. Sachenko, V. P.; Demekhin, V. F. (Rostov-on-Don State Univ., USSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 31: 942-6(June 1967). (In Russian).

Relative probabilities of various transitions in light $(12 \leq Z \leq 18)$ multiply ionized atomic configurations $(1s)\ (2s)\ (2p)^6$ and $(1s)\ (2s)^2\ (2p)^5M$ were studied. The letter M is the M electron whose actual appearance is not essential for the calculations. The LS-bond approximation in which each configuration corresponds to the ^1S, ^2S, and ^1P and ^3P terms are applied to the indicated Z magnitudes. (R.V.J.)

2812 ON MULTIPLE SCATTERING OF SLOW ELECTRONS IN GASES. II. Gavallas, L. A.; Kagan, Yu. M. (Leningrad Inst. of Precision Mechanics and Optics). Izv. Vyssh. Ucheb. Zaved., Fiz., No. 4, 20-3(1967). (In Russian).

Formulas for the scattered electron beams in devices consisting of an electrode source and electrode collector were derived and used for the experimental measurement of the cross section of the angular scattering of slow electrons on atoms of helium, neon, and argon. (tr-auth)

2813 ATOMIC AND MOLECULAR PROCESSES IN THE HELIUM POSITIVE COLUMN. Teter, Michael Phillip. Austin, Tex., Univ. of Texas, 1966. 113p.

Thesis.

The positive column of a helium dc discharge was studied spectroscopically as a function of pressure and current, and a loss process by neutral collision was detected for excited states of helium with principle quantum number equal to three which lay above the appearance potential of the molecular ion. Inelastic excitation transfer was eliminated as the possible cause by selectively increasing the population of a single excited state by absorption of intense resonance radiation and observing the other excited states for an increase in population. The remaining possibility for the pressure-dependent loss process is conversion to molecular ions via the Hornbeck−Molnar process. By comparison of the pressure dependent loss rates with radiative rates, the Hornbeck−Molnar cross sections are determined. Excited molecular states are shown to be populated in the positive column in helium by electron excitation of metastable molecules. At higher pressures in the range 2 to 20 torr metastable molecules are formed primarily by three-body conversion of metastable atoms. The rate coefficient is low (~$0.3P^2$) because of the repulsive potential (~0.03 eV) between the metastable atom and a ground-state neutral. At lower pressures, a second mechanism is effective. The 2^3P excited atom is converted into the $2p\pi$, $^3\Pi_g$ excited molecule by a three-body process. The data permit derivation of the three-body coefficient for this second process. (Disser. Abstr.)

2814 SCATTERING OF A LASER BEAM BY RELATIVISTIC ELECTRONS. Pechacek, Robert Edward. Berkeley, Calif., Univ. of California, 1966. 87p.

Thesis.

Relativistic effects of the scattering of electromagnetic radiation from electrons are discussed, under the assumption that the scattered electric field is a linear function of the incident field. It is shown that the spectral intensity of scattered radiation is proportional to the ensemble average of the product of spectral density of density fluctuations times a function of relativistic origin. This relativistic function depends on the velocity of the scatterer, the position of the observer, and the direction of the incident radiation. The concept of a "restricted particle" is developed to describe scattering that occurs in a finite volume. One

effect of the finite volume is to broaden the spectrum of radiation scattered from a distribution of particles with identical velocities. The width of the broadened line is about (2/T) Hz, where T is the time interval that the particles require to traverse the finite volume. A second effect, which is independent of the size of the finite volume, is a first order (in v/c) difference in intensity between radiation scattered from free particles and from restricted particles. The results are given of a computation of the spectral intensity of radiation scattered from Maxwellian distributions of electrons at temperatures between 25 and 800 keV. Finally an inconclusive experiment to scatter radiation from a mirror machine plasma is described. (Disser. Abstr.)

2815 MEASUREMENTS OF RESONANT ELECTRON CAPTURE IN CLOSE H^+-ON-H COLLISIONS. Helbig, Herbert Frederick. Storrs, Conn., Univ. of Connecticut, 1966. 57p.
Thesis.

Differential measurements of the electron capture probability P_0 are made for protons scattered from atomic hydrogen targets. The incident proton energy ranges from 150 keV down to 0.130 keV and the scattering angle is varied between 0.2 and 6.0°. Seven sharply resonant peaks of P_0 are found, their location depending on both energy and angle. For example, when the scattering angle is held at 6° the peaks are found at 21, 3.9, 1.7, 0.90, 0.54, 0.36, and 0.19 keV, and when the energy is fixed at 0.250 keV peaks are found at 0.7, 1.4, 2.6, and 4.5°. In some cases the equivalent collision with deuterium, $D^+ - D$, is used to augment the range of the measurements. These data extend those reported by Lockwood and Everhart (1962) who studied this same phenomenon in $H^+ - H$ collisions over a smaller range in energy and at fixed 3° scattering angle. Relative differential cross section data are presented also which show a change in slope with the onset of rainbow-angle scattering conditions. (Disser. Abstr.)

2816 CROSS SECTIONS FOR ELECTRON CAPTURE BY FAST PROTONS IN H_2, He, N_2, Ar. Welsh, Leland Merritt. Berkeley, Calif., Univ. of California, 1966. 60p.
Thesis.

Measurements have been made of cross sections for electron capture by protons from 440 keV to 13.75 MeV in N_2 and in Ar, to 5.41 MeV in He, and to 2.45 MeV in H_2. These results are presented along with electron-loss cross sections for the same gases at 1.027 and 2.44 MeV. The measurements were carried out through analysis of particle-beam composition after exit from a gas target of known composition and thickness. The beam was separated magnetically, and the charged and neutral components were detected by Faraday cup and scintillator, respectively. The results overlap, between 440 keV and 1 MeV, the experimental results of Barnett and Reynolds. The σ_{10} cross sections in this region have the same general behavior, but are larger by an amount varying from roughly 10% in hydrogen to 50% in argon than those of Barnett and Reynolds. The results here appear to agree with the prediction of Tuan and Gerjuoy concerning the difference between electron capture by protons in molecular as opposed to atomic hydrogen, although additional measurements will be required to confirm the prediction. There also appears to be a possible correlation between the experimental results in N_2, which show inflections in the capture cross section curve around 1 MeV, and the calculations by Mapleton for capture from that complex atomic system. There is good agreement between theory and this experiment for the electron-loss cross section. (Disser. Abstr.)

2817 EXPERIMENTAL DETERMINATION OF THE SPIN EXCHANGE CROSS SECTION OF ^{39}K AND ^{133}Cs. Stark, Thomas Edison. Ann Arbor, Mich., Univ. of Michigan, 1966. 73p.
Thesis.

A value for the exchange cross section for collisions between potassium atoms (^{39}K) is reported. The measurements employ the standard techniques of electron paramagnetic resonance (EPR). A microwave absorption spectrum is obtained by observing magnetic dipole transitions between various magnetic sublevels of the ground state of a potassium atom, split by the hyperfine and Zeeman interactions. The spin-exchange collision rate is found by measuring the line widths of isolated transitions and the alkali density determined from an absolute calibration of the microwave spectrometer. For the latter measurement, small weighed-out crystals of copper sulfate, $CuSO_4 \cdot 5H_2O$, are used as standards of intensity. The role of spin-exchange collisions as a broadening mechanism for magnetic dipole transitions is examined by means of the density matrix formalism. A suitable equation of motion for the density matrix is established and solutions appropriate to the Paschen–Back region of the Zeeman interaction are obtained. Expressions are obtained for the imaginary part of the complex susceptibility, which is related to the microwave power absorbed by the potassium atoms, and for the contributions of spin–lattice and spin–spin relaxation to the observed line width. The spin-exchange cross sections for collisions between ^{39}K atoms is 1.45×10^{-14} cm^2, with an assigned probable error of ±20%. Also reported is a value for the exchange cross section for cesium (^{133}Cs). In the case of cesium the hyperfine coupling is sufficiently strong that the Paschen–Back region is not reached for magnetic fields corresponding to the use of X-band microwaves. This is the so-called intermediate field case and results in appreciable mixing of the electron spin states by the hyperfine interaction. Certain corrections in the density matrix treatment follow thereby and are discussed in an appendix. The measured value of the exchange cross section for ^{133}Cs is $1.8_1 \times 10^{-14}$ cm^2, with an assigned probable error of ±20%. (Disser. Abstr.)

2818 RASSEYANIE ELEKTRONOV NA ATOMAKH. IV. ATOMNYE STOLKNOVENIYA. (Scattering of Electrons on Atoms. Volume IV. Atomic Collisions). Veldre, V. Ya. (ed.). Riga, Izdatel'stvo Zinatne, 1967. 140p.

Seven articles are included on the problems of elastic scattering, excitation, and ionization. A modified strong-bond method is suggested for resolving the problem of long-range interactions. The threshold behavior of ionization, asymptotic behavior of the wave function for a charged-particle system, and cross sections of slow electron elastic scattering on alkali metal and hydrogen atoms are discussed. The radial-equation system for electron collisions with inert gases is analyzed, and application is made specifically to the neon atom. An improved approximation method for computing effective cross sections of electron collisions with atoms is evaluated. (R.V.J.)

2819 TRANSMISSION SPUTTERING OF THIN FILMS BY LOW-ENERGY HYDROGEN IONS. Robison, Charles Howard. Davis, Calif., Univ. of California, 1966. 105p.
Thesis.

A transmission sputtering experiment was performed with 15-keV molecular ions of hydrogen and deuterium normally incident on polycrystalline gold films several hundred angstroms thick. The sputtered atoms were detected by using neutron activation. The data were compared to theoretical models of Keywell, Roi et al., and Pease. A modified form of Pease's sputtering formula was found to fit the data within a factor of two, except in the circumstance where the average range of the primary knock-on atom is less than the displacement energy. The modifications included: the energy loss of the incident particles in passage through the film; the average energy of the moving primary knock-on atoms; and the incident beam scattered before reaching the downstream face of the film. An energy analysis of the sputtered gold ions was attempted for one particular set of parameters using a parallel-plate, electrostatic energy analyzer. A mean energy of 3 eV for the negatively charged gold ions sputtered from the target was observed for 15 keV D_3^+ incident on a 500 A° gold film. (Disser. Abstr.)

Cosmic Radiation

Refer also to abstracts 2417, 2734, 2913, 3452, and 3461.

2820 ELIMINATION OF VARIOUS CONTRADICTIONS IN THE DATA ON COSMIC RAYS AT ENERGIES ABOVE 10^{11} eV BY MEANS OF THE HYPOTHESIS ON THE EXISTENCE OF A PASSIVE BARYON STATE. Smorodin, Yu. A. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1644-7(Oct. 1966). (In Russian).

The data obtained by means of N. L. Grigorov's ionization calorimeter lead to an assumption which differs markedly from that based on other methods. In order to reconcile the contradictions, it is suggested that at the time of the interaction the nucleon assumes a passive S state, in which the nuclear interaction cross section is much smaller than the normal geometric cross section. In such a state, the baryon exists for a period τ of the order of 10^{-11} sec, after which it passes into the normal state. The derivation showed that most of the previous contradictions in the experimental data with cosmic-ray nucleons could be explained on the basis of this assumption; the irregularities in the spectra of wide atmospheric showers concerning the number N of particles in the $N = 10^5$ to 10^7 range could also be reconciled. It is considered possible that such passive-state baryons are present in the cosmic-ray flux at great depths below the surface; the theory explains the recently discovered wide angular distribution of charged particles and particle showers at great depths. (TTT)

2821 INVESTIGATION OF NUCLEON INTERACTIONS WITH $\geq 10^{14}$ eV ENERGIES. Antonov, R. A.; Apanasenko, A. V.; Baradzei, L. T.; Kanevskaya, E. A.; Rykov, V. V.; Smorodin, Yu. A.; Solov'ev, M. V.; Sorokin, O. N.; Tulinova, Z. I. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1640-3(Oct. 1966). (In Russian).

Currently used methods for the study of nucleons with energies

of 10^{14} eV or higher are based on the detection of γ quanta generated during the interaction by determining the total γ-ray flux in the atmosphere, examining the γ-quanta (π^0 mesons) above the instrument, or investigating wide atmospheric showers during the initial stages of the nuclear cascade. A device was developed for the purpose of carrying out all of these types of studies within a single experiment; it included scintillation counters, spark chambers, and Cherenkov counters and nuclear emulsions. The system was installed on board an airplane; the measurements were checked every 5 minutes by means of a reference signal. The energy of the electron–photon showers was determined by comparison of the intensity of the Cherenkov radiation, density distribution of the x-ray film, and spatial distribution measurements of the electrons in the showers. The measurements were carried out at an altitude of 10 km, within 5 hours; only the showers in which at least 3 particles were recorded in the spark chamber were included in further studies; in all cases considered, the density of all particles exceeded about 100 particles/m^2. The experimentally obtained angular distributions agreed with calculated values, confirming the authors' earlier conclusions concerning the upper-layer behavior of vertical shower fluxes. (TTT)

2822 COMPARISON OF THEORETICAL CALCULATIONS AND EXPERIMENTAL DATA ON THE FORMATION OF WIDE ATMOSPHERIC SHOWERS IN THE UPPER PART OF THE ATMOSPHERE. **Antonov, R. A.; Smorodin, Yu. A.; Tulinova, Z. I. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1637-9(Oct. 1966). (In Russian).**

The data obtained from experimental studies of wide atmospheric showers which indicate the energy distributions in nuclear interactions were compared with the theoretical calculations of L. G. Dedenko. The calculations were based on models postulating the formation of secondary particles by means of 1, 2, or more fireballs at a set primary particle energy, considering the nucleon composition of the primary component of the cosmic rays. The comparison included a consideration of the number of π^0 mesons, and the behavior of atmospheric showers. The study indicated that there is a fairly large number of fireball-model type interactions which result in a small dissipation of energy. The experimental data were laying closer to the theoretical values for models based on a moderate dissipation of energy; these calculated values agreed with data collected in mountain and sea-level stations. On the other hand, theoretical studies for high altitude interactions, based on a single disintegration scheme of the nucleus were unable to explain the experimental data. (TTT)

2823 ABSORPTION OF NUCLEAR COMPONENT ENERGY FLUX IN IRON. **Erofeeva, I. N.; Mishchenko, L. G.; Murzin, V. S.; Rapoport, I. D. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1628-9(Oct. 1966). (In Russian).**

The ionization calorimeter was used to study the changes of the energy flux with depth X at various primary-particle energies. Assuming that the probability of generating various pions is the same, at high secondary-particle energies, the value of β, the portion of the energy used up by pions for the generation of π^0 mesons or strongly ionizing particles is $\beta = 1/3$, and the energy absorption $S(X)$ of the nuclear-active particles is $S(X) = \exp(-X/3L)$, whereby L designates the free path of the interacting pions. This problem was examined in a generalized manner. The boundary value of β is 1 and the expression in that case becomes $S(X) \approx \exp(-X/L)$. The ionization due primarily to electrons and strongly ionizing particles, and not the energy flux of the nuclear component, was directly determined by the ionization calorimeter. Study of the interaction of particles with energies within the E_0 = 200 to 400 BeV and above 700 BeV indicated that at the depth of $X < 400$ g. cm^{-2}, the absorption takes place with a value of $\beta \approx$ to 1/3, while at $X >$ than 400 g. cm^{-2} the value of β was 1. It was concluded that at such high energies a considerable portion of the energy at all depths is transmitted by strongly ionized particles; otherwise the value of β would be $\sim 1/3$. (TTT)

2824 HIGH-ENERGY γ RAYS PRODUCED BY NUCLEON INTERACTIONS. **Smorodin, Yu. A. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1630-6(Oct. 1966). (In Russian).**

During the period between the Jaipur (1963) and London (1965) conferences on cosmic rays, three main approaches have been used in investigations: (1) Study of the electron–photon fluxes and energy spectra at various depths in the atmosphere, considering the energy of the individual π^0 mesons generated in the interactions and the total energy transferred to all of the π^0 mesons; (2) Study of the formation of π^0 mesons in separate interactions; and (3) Examination of the γ-quantum clusters formed in nuclear interactions in the atmosphere above the γ detectors. Emulsion chambers were used for research in the stratosphere; the instruments involved in studies on board aircraft included γ detectors, x-ray emulsion, Cherenkov counters and scintillation counters. The energy spectra of nuclear cascades and γ quanta recorded at pressures of 20 g. cm^{-2} agreed with earlier values. The spectra obtained in mountain experiments at pressures of 540 and 740 g. cm^{-2} yielded lower values than those expected on the basis of primary flux data and from earlier mountaintop experiments. It may be stated that many of the earlier experimental difficulties encountered in this field have been overcome. (Review article, 11 references). (TTT)

2825 CERTAIN SINGULARITIES OF PION AND NUCLEON INTERACTIONS WITH NUCLEI. **Erofeeva, I. N.; Mishchenko, L. G.; Murzin, V. S.; Sarycheva, L. I. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1624-7(Oct. 1966). (In Russian).**

Experiments were carried out with an ionization calorimeter for the purpose of determining the energy distribution of the portion of the energy transferred by photons in the collision of nuclear-active cosmic-ray particles with various nuclei. The energy of the photons generated in the interaction was determined by means of 2 or 3 rows of ionization chambers separated by thin layers of lead. 195 events of interaction of the primary nuclear-active particles with the nuclei of carbon, iron, and lead were analyzed. The most probable value of the inelasticity coefficient in the collision of the primary particles with carbon nuclei was found to be $\alpha_\gamma \approx 0.1$; with heavy nuclei the value found was $\alpha_\gamma \approx 0.15$ to 0.3. A marked difference was observed in the interaction of pions and nucleons with the various nuclei. The properties of pion–nucleus collisions in the 10 to 1000 BeV range were found to be similar in view of the fact that two types of interactions are involved and the energy spectra of the secondary photons were alike. In collisions with high α_γ values which may be viewed as noncentric collisions, a sharp collimation of the forward secondary pions was observed. (TTT)

2826 MECHANISM OF FORMATION OF HIGH-ENERGY PIONS IN COSMIC RAYS. **Grigorov, N. L.; Shestoperov, V. Ya.; Brikker, S. I.; Podgurskaya, A. V.; Savel'eva, A. I.; Sobinyakov, V. A.; Poperekova, L. M.; Plekhova, A. I. (Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1621-3(Oct. 1966). (In Russian).**

A system consisting of a 10-m^2 ionization calorimeter and 3 rows of nuclear films placed under 1, 2, and 3-cm thick sheets of lead was used for the study of high-energy pions at an altitude of 3200 m; a graphite layer placed 156 cm above the nuclear film served as the π^0 meson generator. The showers generated in the graphite involved energy transfer of the order of $>10^{12}$ eV. It was not possible to determine the nature of the generated particle with the apparatus used; therefore, the characteristics of these showers were compared with data obtained by other authors at a height of 30 km., where the portion of pions in the nuclear-active flux was very small. It was concluded from the data that the detected showers were generated either by high-energy nucleons or by pions. It was also found that none of the particles generated in the highest-energy portion of the spectrum possess an energy much higher than that of the remaining particles. The results confirmed the assumption of other authors that the π mesons carrying about 50% of the energy of the primary particles are generated by the decomposition of isobars into a nucleon and a π meson. (TTT)

2827 STUDIES OF ELECTRON–PHOTON CASCADE SHOWERS IN IRON AND LEAD AT ENERGIES EXCEEDING 100 BeV. **Babaev, M. K.; Baigubekov, A. S.; Denikaev, R. Z.; Emel'yanov, Yu. A.; Lukin, Yu. T.; Takibaev, Zh. S.; Khomenko, G. S. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1604-7(Oct. 1966). (In Russian).**

An ionization calorimeter consisting of 12 series of chambers separated by an absorber of iron or lead was used to record electron–photon showers; the thickness of the absorber was so chosen as to attenuate practically completely the cascade showers generated by 100-BeV primary particles. A graphite block helped to separate photon showers from nuclear active particles. 187 showers in iron and 131 in lead, with energies between 100 and 300 BeV, interpreted as being of the electron–photon type were studied closely, plotting mean cascade curves standardized to 100 BeV. The experimental data for iron confirmed the values of $t_0(Fe) = 12.6$ g cm^{-2}. No conclusions could be drawn concerning the lead. The study showed that the energy of the cascade shower from the total number of particles yields more reliable data than energy determinations based on the number of particles at the point of the maximum. (TTT)

2828 INELASTIC INTERACTIONS OF COSMIC RAY PARTICLES WITH LEAD NUCLEI. **Azimov, S. A.; Kochetkov, G. A.; Kratenko, Yu. P.; Mamurov, A. M. (Tashkent State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1608-9(Oct. 1966). (In Russian).**

The portion of the energy transmitted by π^0 mesons during the initial part of the interaction of cosmic particles with lead nuclei

was measured by means of an ionization calorimeter, consisting of an argon-filled steel container. Layers of lead separated by steel rods were placed in the upper portion of the system; the lower part contained 5 sets of ionization chambers. The system operated whenever the total pulse from all except the upper ionizing chamber exceeded a certain preset value and a double coincidence took place in the upper counters. The measurements were carried out at an altitude of 3160 m. Analysis of the 59 events, the energy of which exceeded 100 BeV with less than 100 particles passing through the first part of the system, revealed a value of $\underline{K}_{\pi^0} = 0.24 \pm 0.02$ for the differential distribution; this agreed with values calculated for the model of successive interaction of high-energy nucleons with compound nuclei, assuming that the inelasticity of $\underline{NN}$ interactions of $\underline{K}_\pi = 0.3$. (TTT)

2829 STUDIES OF IONIZATION BURSTS AT THE MOUNTAIN LEVEL. Babayan, Kh. P.; Dulyan, G. A.; Sobinyakov, V. A.; Tret'yakova, Ch. A.; Shestoperov, V. Ya. (Moscow State Univ. Inst. of Physics, Moscow). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1614-16(Oct. 1966). (In Russian).

Using the authors' previously described 10-m^2 ionization calorimeter, ionization bursts in ionization chambers which create the nuclear-active particles falling on the system from the air, were studied at an altitude of 3200 m. In every case, the energy, $\underline{E}_{\pi^0}$, of the π^0 mesons formed by the interaction of nuclear-active particles in the upper filter, and the residual total energy of the primary particles and $\underline{E}_{n\pi}$ of the secondary particles formed by the interaction of the secondary nuclear-active particles, were determined This made it possible to calculate the total energy of the primary particle and the portion $\epsilon = \underline{E}_{\pi^0}/\underline{E}$ transferred to it by π^0 mesons during the interaction in the upper filter. In order to determine the direction of an electron–nucleon cascade in the calorimeter, the ionization had to be observed by at least 2 chambers. The average value of ϵ in events examined was 0.63 ± 0.01, corrected to true value of $\epsilon = 0.58 \pm 0.01$; this confirmed earlier results. It was found that the probability that the particle will transfer more than one-half of its energy to the electron–photon component is 0.46; for transfer of more than 70% of the energy, the value found was 0.17. Ott's cascade curves for lead were used, calculating the energy transfer by π^0 mesons. (TTT)

2830 EVALUATION OF EFFECTIVE CROSS SECTIONS OF INELASTIC INTERACTIONS OF PRIMARY 10^{12} eV PROTONS WITH ATMOSPHERIC ATOMIC NUCLEI. Babayan, Kh. P.; Grigorov, N. L.; Dulyan, G. G.; Sobinyakov, V. A.; Tret'yakova, Ch. A.; Shestoperov, V. Ya. (Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1617-20(Oct. 1966). (In Russian).

Estimation of the free path of interaction of nucleons in the air requires the determination of the nuclear-active particle flux in the atmosphere not accompanied by showers. Such measurements were carried out at an altitude of 3200 m, using a 10-m^2 ionization calorimeter, consisting of 12 series of ionization chambers, laid out on the lead, graphite, and iron filters. More than 200 G-M counters placed in the upper layers of the system were used to read the showers. The cases selected for study did not exhibit ionization in the 2 upper layers. After determining the integral energy spectrum of individual nuclear-active particles, it was found that when the energy increases from 10^{11} to 3×10^{12} eV, the inelastic interaction cross section of nucleons with the nuclei of the atoms of the atmosphere increases by a factor of 1.3. (TTT)

2831 ENERGY AND ANGULAR CHARACTERISTICS OF NUCLEAR INTERACTIONS AT 23 AND 150 TO 500 BeV ENERGIES. Galstyan, D. A.; Zhdanov, G. B.; Tret'yakova, M. I.; Chernyavskii, M. M.; Shcherbakova, M. N. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1598-1601(Oct. 1966). (In Russian).

The nuclear interactions of 24 BeV/sec pulse protons were studied by means of 600μ thick Ilford G5 photoemulsion, exposed to the proton beam of CERN in a 180 kgauss pulsed magnetic field. During the study and identification process, most of the secondary charged particles were suppressed. From the data collected, 180 quasinucleonic interactions were selected on the basis of the criterion $\underline{N}_b + \underline{N}_g \leq 3$; $\underline{N}_g \leq 1$. The total neutron–meson pulse was calculated either from the total pulse of 2 protons or from the equilibrium of the mean pulses, assuming that the mean proton and neutron pulses are equal. It was found that the inelasticity of events with low ($\underline{n} \leq 4$) and large ($\underline{n} \geq 5$) plurality differ sharply; the low plurality of neutral, $\pi^0 + \underline{K}^0$ mesons carry away much more energy than the π^+ mesons and especially than the π^- mesons. Analysis of the experimental data on the interactions with any given $\underline{n}$ indicated that the transversal pulse of protons $\underline{p}_\perp$ is about 1.5 times larger than the $\underline{p}_\perp$ value of mesons. This latter value increases strongly as the inelasticity coefficient of the interaction increases. The very low values of $\underline{p}_\perp$ ($\leq 0.05\mu$ sec) obtained for energies between 150 and 500 BeV, are probably due to the characteristics of the apparatus as they are related to the determination of the axis of the shower along the center of gravity of the secondary particles. (TTT)

2832 TRANSVERSE MOMENTUM. Volzhenskaya, V. A.; Sarycheva, L. I. (Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1594-7(Oct. 1966). (In Russian).

The transverse pulse experienced by secondary particles when they are generated by the collision of 2 nuclear-active particles, considered Lorentz invariant, yields information on the mechanism of interaction of nuclear-active particles. The process is best described by the hydrodynamic theory. The currently available experimental data from cosmic-ray studies were compared with results of this theory. It was found that a transverse pulse distribution of secondary pions generated by the interaction of primary particles with $\underline{E}_0 > 10^{12}$ eV with a nuclei agrees better with the theoretical values when the hydrodynamic scattering of the system was not taken into account. It was confirmed that the transverse pulse of secondary particles is a reliable characteristic of a nuclear interaction. Changing the energy of the primary particles by 2 orders of magnitude, the transverse pulse changed only by 30%; it was found to be only slightly dependent on the emission angle of the secondary particles. A stronger correlation was noted with the mass of the secondary particles. (TTT)

2833 DIRAC MONOPOLE. Dorman, L. I.; Okulov, Yu. I. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1590-3(Oct. 1966). (In Russian).

The authors concluded earlier that the bond constant of the scalar magnetic charge with the electromagnetic field must be less than $e^2/\hbar c$, and that the neutrino should have such a charge. It is shown that on the basis of experimental conservation-law data derived from elementary particle interactions, it may be concluded that the magnetic scalar charge g is weak. The more the conservation laws are satisfied in a given interaction, the stronger that interaction must be. There is a similarity as far as the conservation laws are concerned between the interaction of the Dirac monopole with the electromagnetic field and the nuclear interactions; the same situation prevails between the weak, 4-fermion interaction and the interaction of the scalar magnetic charge with the electromagnetic field. Inasmuch as the number of the conservations laws for the interaction of scalar magnetic charge g with the electromagnetic field is much less than the same number in the ordinary electromagnetic interaction of the electric charge e, the inequality $g < e$ is expected to prevail. (TTT)

2834 CHARACTER OF PERIPHERAL INELASTIC PROCESSES. Akimov, V. N.; Dremin, I. M.; Roizen, I. I.; Chernavskii, D. S. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1584-6(Oct. 1966). (In Russian).

The general principles of the theory of peripheral interactions were reviewed without making use of concrete models, and deriving the necessary information on inelastic processes on the basis of unitary conditions, employing the optical theorem. This approach made it possible to consider available data on the properties of the amplitude of elastic interactions, such as analytical properties, dispersive relations, and the method of complex orbital moments. It was concluded from the derivations that the fireball may not be considered as an ordinary resonance. For a more refined study, model representations must be used. In one of the models considered, the asymptotic evaluation of the fireball differs markedly from nonasymptotic cases. (TTT)

2835 ROLE OF SUCCESSIVE INTERACTIONS IN GENERATION OF THE JETS IN COMPOUND NUCLEI. Artykov, I. Z.; Barashenkov, V. S.; Dubrovina, S. A.; Eliseev, S. M.; Slavatinskii, S. A. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1581-3(Oct. 1966). (In Russian).

At energies of several hundred BeV, the transversal dimensions of the pion beam generated by nucleons within the nucleus coincides with the dimension of the nucleon. This makes it possible to study the interaction of the beam with individual nucleons of the target nucleus. In the case of the formation of pions by means of resonances (fireball), information may be obtained on the inelastic scattering of these resonances on compound nuclei. In order to study the interaction of nucleons with nuclei, the internuclear cascade in a nucleus with $\underline{A} = 70$ and $\underline{R} = 1.4\ \underline{A}^{1/3} \times 10^{-13}$ cm, corresponding to the mean nucleus in a photoemulsion, was investigated. This nucleus is closed to the iron and copper nuclei, for which cosmic-ray data are available. The Monte Carlo computer calculations with 3 dimensional relativistic kinematics were based on the Fermi gas model. The nucleon–pion interaction data up to 30 BeV derived from accelerator experiments, and at hundreds of BeV, resulting from the Pamir nucleon–nucleon collision experiments, were used in this study. It was found that the intranuclear cascade model, with and without consideration of the

cascade interaction of the fast nucleon, did not yield values in agreement with experimental data. This is probably due to the fact that the multiparticle interaction of the pions with the nucleons of the target nucleus was not taken into account. It should be also kept in mind that the pion beam (or fireball) has a low interaction cross section within the nuclear matter. (TTT)

2836 NEW INSTALLATION FOR STRONG INTERACTIONS AT 100 TO 1000 BeV ERECTED AT TYAN-SHAN SUMMIT STATION. THE FIRST DATA. Guseva, V. V.; Denisov, E. V.; Dobrotin, N. A.; (and others). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1574-6(Oct. 1966). (In Russian).

A new installation was placed in service at the Tyan-Shan station at an altitude of 3340 m; it represented an improved version of the earlier system and was designed for studying strong interactions of nucleons and pions in cosmic radiation in the 100 to 1000 BeV range. It included 2 Wilson chambers and hodoscopic counters which made it possible to determine the presence of charges on primary particles. A system was designed for determining the ionization energy of primary protons and pions in this range and to calibrate an ionization calorimeter consisting of 500 recording channels and the necessary supplementary systems. The range of the recorded pulses corresponded to the formation of 2×10^4 to 4×10^7 ion pairs in the chamber. An LiH film, placed directly under the Wilson chamber, served as a target. The particle shower was recorded in the 5000-gauss magnetic field of the Wilson chamber. The first data obtained with the new system confirmed earlier conclusions concerning the asymmetric scattering of secondary particles, formation of a large number of π mesons resulting from the decay of a moving fireball and the generation of isobars. (TTT)

2837 EXISTENCE OF A FIREBALL. Dobrotin, N. A.; Slavatinskii, S. A. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1566-73(Oct. 1966). (In Russian).

The term "fireball" is used to designate hypothetical meson resonances produced by strong interactions at energies of hundreds and thousands of BeV and characterized by the absence of baryon charge, isotropy of the angular distribution of the decay products, and a short specific time of life; they yield pions as decay products. The fireball possesses a discrete mass, although it may also be considered as an excited meson cloud without a discrete mass. The authors' Pamir data indicate that this mass is about 0.4 BeV. A review of the earlier data concerning the multiple generation of most of the secondary particles confirmed the assumption of the actual existence of fireballs. However, it was found that if they consist of series of neighboring resonances with discrete masses, the question concerning the existence cannot be unequivocally resolved; further tests must be made with higher energy accelerators. (TTT)

2838 PRIMARY COSMIC SUPER-HIGH ENERGY RADIATION AND WIDE ATMOSPHERIC SHOWERS. Khristiansen, G. B.; Abrosimov, A. T.; Atrashkevich, V. B.; Belyaeva, I. F.; Kulikov, G. V.; Mandritskaya, K. V.; Solov'eva, V. I.; Fomin, Yu. A. (Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1690-3(Oct. 1966). (In Russian).

A continuing study is being carried out concerning the determination of the characteristics of wide atmospheric showers. The factors considered include energy spectra, chemical composition, and anisotropy of primary cosmic rays in the energy range of $E_0 > 10^{15}$ eV. Measurement of the number of particles N_e revealed that near $N_e \lesssim 10^6$, the exponent of the integral spectrum in the exponential law changes from 1.5 to 2. This study was extended to the $E_0 \geq 10^7$ region. It was found that the exponent tends to decrease at that level. A new method for studying wide atmospheric showers with a set number N_μ of high-energy μ mesons ($E_\mu \geq 10^{10}$ eV) was also developed. The correlation between N_μ and E_0 was more definite than that between N_e and E_0; thus the transition from the wide atmospheric shower spectrum to the primary energy spectrum is quite unambiguous. The showers chosen for study contained N_μ values, about 70% of which was due primarily to intermediate and heavy nuclei. These showers with $N_\mu \geq 10^4$ and zenith angles of $\theta \leq 45°$ exhibited a Pearson coefficient of $P(\chi)^2 = 0.4$ concerning the probability of agreement between experimental distribution and isotropic value. The anisotropy was also investigated in showers with $N_e < \overline{N}_e$ for a given N_μ value, involving ~90% contribution of intermediate and heavy nuclei; however statistical errors made it impossible to draw conclusions concerning an anisotropy of ~15%. (TTT)

2839 MEASUREMENTS OF MUON FLUX AT THE DEPTH OF 20 mwe BY MEANS OF SPARK CHAMBER. Stoyanova, D. A.; Strakhov, V. A.; Khrenov, B. A. (Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1697-9(Oct. 1966). (In Russian).

Measurement of narrow muon beams in wide atmospheric showers requires the use of large-surface (≥10 m²) detectors which are able to record individual particles; the spark chamber is especially well suited for this purpose. A system consisting of two chambers with external electrodes and filled with neon under atmospheric pressure was built to make such studies; it was controlled by coincidence pulses from a battery of counters. The photographic pictures were taken from the top and from the side. After 3200 hours of operation at 20 mwe, 655 events involving passage of muons were recorded. Measurements of the zenithal angles revealed that 70% of the pairs possessed angles differing by less than 5°, agreeing with the expected lack of parallelity of the muons because of ground scattering. The system allowed to determine the direction of wide atmospheric showers. Experiments were also carried out at a depth of 40 m, demonstrating the feasibility of joint operation of spark chambers, G–M counters in a hodoscope, and ionization chambers. (TTT)

2840 IONIZING LUMINESCENCE OF AIR AND POSSIBILITY OF USING IT FOR RECORDING WIDE ATMOSPHERIC SHOWERS. Belyaev, V. A.; Chudakov, A. E. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1700-2(Oct. 1966). (In Russian).

Earlier studies by the authors on the ionization luminescence yield of air in wide atmospheric shower flareups indicated that examination of that phenomenon is one of the most promising methods for recording high-energy showers. In this experiment, the luminescence was excited in a leaktight aluminum chamber, recording the event through a transparent window by means of a photomultiplier. A collimated 1-MeV electron beam from the decay of ^{32}P was directed onto a stilbene crystal connected to a second photomultiplier, making it possible to determine coincidences and the duration of the luminescence. Results obtained for luminescence in air, nitrogen, and argon at pressures ranging from 0 to 1 atmosphere indicated that the nitrogen is the basic luminescent component of air. Only the visible portion of the luminescence may be used for recording wide atmospheric showers, even though unfortunately the intensity in the visible range is very low. The energy threshold of recording was calculated to be 3×10^{19} eV; at $E = 10^{20}$ eV good results may be expected. (TTT)

2841 RADIATION IN WIDE ATMOSPHERIC SHOWERS PRODUCED BY SLOW PARTICLES. Rozental', I. L.; Fil'chenkov, M. L. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1703-4 (Oct. 1966). (In Russian).

The mechanisms involved in the emission of wide atmospheric showers which could indicate isotropic or quasi-isotropic radiation, were reviewed, estimating also the bremsstrahlung of the electronic component of the showers. An expression was derived for calculating the number of emitter photons for a 1 g cm^{-2} path. The finding agreed with the values obtained by means of another approximation. The obtained estimates were also compared with the observed intensity of the flareups reported by J. V. Jelley et al., finding that they were markedly higher. However, it must be kept in mind that because of its quasi-isotropic nature, the radiation falls on an area that is larger than the surface of the antenna. Thus, if the effective surface S is 1 km², an energy of $\sim 10^{12}$ erg reaches the antenna; for S ≈ 10 km² this value becomes $\sim 10^{-13}$ erg. (TTT)

2842 CALCULATION AND STUDIES OF LONGITUDINAL AND TRANSVERSE DEVELOPMENT OF WIDE AIR SHOWERS. Khristiansen, G. B.; Atrashkevich, V. B.; Kalmykov, N. N.; Fomin, Yu. A. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1708-12 (Oct. 1966). (In Russian).

The development of wide atmospheric showers in the longitudinal and transverse directions on the basis of data collected at sea level was analyzed by the Monte Carlo method. Calculations of the longitudinal growth from the boundary of the atmosphere to sea level revealed irregularities which were related to the strong fluctuations of the place of interactions and the interaction inelasticity coefficient of the controlling nucleon. Examination of the fluctuations of the electron-components at various altitudes, such as 200 g cm^{-2} (airplane experiments); 650 g cm^{-2} (Pamir experiments); 1030 g cm^{-2} (sea level tests) revealed a change of the sign of the correlations between N_e and S, the growth of the shower, when passing from the stratosphere to sea level. Calculation of the transverse growth was found to be more difficult, but using some simplifying assumptions, results were obtained for the mesons and electron–photon components. A method was developed for determining the primary particle energy E_0 and the atomic number A, without using special models. (TTT)

2843 REMARKS CONCERNING A MODEL OF DEVELOPMENT OF WIDE AIR SHOWERS. Babayan, Kh. P.; Boyadzhyan, N. G.; Grigorov, N. D.; Nymmik, R. A.; Shestoperov, V. Ya. (Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1713-15(Oct. 1966). (In Russian).

The energy of the controlling particles at the level of observation is a very important parameter for studying the growth of wide

atmospheric showers. For this reason, the energy spectra of such particles in showers with $N_s = 10^5$ observed at an altitude of 3200 m were calculated, using the characteristics employed by L. G. Dedenko et al. Three different inelasticity coefficients K were used for calculating the energy spectra. A system consisting of a large ionization calorimeter, 10 scintillation counters, and 220 G–M counters was used for measuring the energy of nuclear-active particles. It was found that in the axis of the showers 10 times fewer particles with $E \geq 10^{13}$ eV were observed than could have been expected if the showers had been generated by a large number of interactions of the controlling particles with the nuclei of the atoms of the air. Thus the contribution of the controlling particles to the generation of wide atmospheric showers in the lower third of the atmosphere amounts to only ~10%. (TTT)

2844 ROLE OF ISOBAR PIONS IN THE DEVELOPMENT OF WIDE AIR SHOWERS. Dedenko, L. G. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1716-18(Oct. 1966). (In Russian).

The author carried out calculations earlier on the mean characteristics of wide atmospheric showers based on various models of the interactions of nucleons with the nuclei of atoms of the air; the two- and many-fireball models yielded the closest values to experimental data. The calculations were extended to the interaction of nucleons and pions with air nuclei at accelerator energies, using the data reported by G. Cocconi et al. The correlation was found to be tenuous; the mean characteristics of the showers depended only on the mean effective hardness of the spectrum of the secondary particles in the elementary act. However, showers with a set number of electrons in the lower third of the atmosphere are generated by nucleons experiencing fewer collisions in the atmosphere and in such cases the isobaric pions play an important role. (TTT)

2845 INTERACTION OF SOLAR NEUTRINO WITH ELECTRONS. Domogatskii, G. V.; Zatsepin, G. T. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1682-4(Oct. 1966). (In Russian).

It was deemed possible to make use of solar neutrino fluxes of the Born cycle for examining the (ve)(ve) scattering processes. The work was carried out by comparing the anticipated effect with that resulting from the scattering of antineutrinos of electrons on the basis of the weak interaction theory. The calculation indicated that high-energy electrons are emitted within a very narrow cone with respect to the direction of the incident neutrinos. The course of the differential cross section of formation of the E > 6 MeV electrons was graphically compared with the angular distribution of the (ν̄e)(ν̄e) scattering process, referring both to the Born cycle. The problem of experimental determination by means of spark chambers and gas-discharge counters is also reviewed. If the effect of the (ve)(ve) scattering could be verified, the results could be used to design a neutrino telescope for observing very remote objects. (TTT)

2846 ABSORPTION CURVE AND ENERGY SPECTRA OF HIGH-ENERGY MUONS. Zatsepin, G. T.; Mikhal'chi, E. D. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1679-81(Oct. 1966). (In Russian).

On the basis of the experimental form of the spectrum of muons reaching a layer of dense material, the absorption problem may be solved approximately, taking into account discrete energy losses, by introducing 2 supplementary coefficients in the expressions used. It was assumed that the mean contribution of the muon intensity with a given energy e at a depth x is due to muons which at x = 0 possesses a predetermined energy; the values derived agree with the most probable values of primary muons. From the measured intensity at a given depth, the muon intensity corresponding to the energy level at the boundary of the material may be calculated. The derivations were carried out at an energy region of $>3 \times 10^{12}$ eV. For further study, more detailed knowledge of the muon energy losses must be available, especially as far as pair formation is concerned. (TTT)

2847 SPATIAL AND ANGULAR DISTRIBUTION OF PARTICLES IN ELECTROMAGNETIC SHOWERS GENERATED BY μ MESONS. Gedalin, E.V. (Inst. of Physics, Tbilisi, USSR). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1677-8(Oct. 1966). (In Russian).

In view of the widespread use of multilayer spark chambers which record the ionizing bursts generated by muons in the absorber, it is desirable to know the spatial and angular distribution function of particles in electromagnetic showers. Therefore, the two dimensional picture of an electromagnetic shower formed by high-energy muons in a light material was closely examined. The muon scattering was neglected in the calculations, which involved determination of the average number of electrons at a given depth t in the shower formed by muons possessing an energy of E_μ. The required data were taken from functions of the cascade theory of electron-photon showers. The expressions obtained made it possible to determine the spatial and angular distribution. The first term of the equation obtained referred to the portion attributable to the continuous pair formation, and the second term to the bremsstrahlung of the muon. (TTT)

2848 PROBLEM OF ANGULAR DISTRIBUTION OF μ MESONS. Il'ina, N. P. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1674-6(Oct. 1966). (In Russian).

The author has determined in earlier publications the angular distribution of muons in a dense layer for two methods of generation: the decay $\pi \rightarrow \mu + \nu$ and $K \rightarrow \mu + \nu$. Using the expression arrived at, the angular distribution of muons was plotted for various depths, taking into account the fluctuation of muons resulting from the $\pi\mu$ decay. The theoretical values obtained were compared with the experimental data reported by C. V. Achar et al. Good agreement was noted; unfortunately, the experimental data were obtained at great depths at which there was no difference in the angular distribution attributable to differences in the types of particles generating the muons. (TTT)

2849 ENERGY SPECTRA OF SHOWER ELECTRONS IN VARIOUS MATERIALS TAKING INTO ACCOUNT POLARIZATION OF MEDIA AND MULTIPLE SCATTERING. Ivanenko, I. P.; Samosudov, B. E. (Moscow State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1651-6(Oct. 1966). (In Russian).

The effect of scattering and the energy dependence of the photon absorption coefficient on the energy spectra of low-energy cascade particles is not sufficiently well known; therefore, the integral spectra of shower electrons in copper, iron, aluminum, and graphite were determined by means of the moment method; the wide-angle multiple scattering approximation was used, taking the energy dependence of the coefficient of the total absorption of photons into account. The cross section of electron bremsstrahlung was used taking into account the polarization of the environment. The approximation method used gave satisfactory results within an error of ~5 to 10%. It was found that scattering affects the shape of the curve of aluminum and graphite to a lesser extent than that of copper and iron. (TTT)

2850 INVERSE PROBLEM IN THE THEORY OF NUCLEAR CASCADES. Astaf'ev, V. A.; Ivanenko, I. P. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1657-61(Oct. 1966). (In Russian).

The initial solution of the inverse problem in cascade theory has been previously demonstrated in the case of electron–photon cascades, solving the direct problem. In order to extend the considerations used for the case of nuclear cascades the spectra of particles at a given depth in the atmospheric showers generated by primary particles must be known. This problem was examined by using an analytically simple model of the interaction function, deriving the spectrum at the desired depth by solving the direct problem. It was assumed that the solution had been obtained experimentally and on the basis of these data the energy moments of the original model function were determined allowing to solve the inverse problem. As cascade process generated in a layer of nuclear-active particles with an energy E_0 incident at the boundary was considered in the calculations, assuming that it contained only one type of nuclear active particles and that a shower develops only in one dimension. The interaction of the particles with a nuclei of the material was characterized by the absorption coefficient μ, the energy spectrum of the secondary particles $n(E',E)dE$, and the coefficient α; the latter indicates the portion of particles generated on the nuclear-active component. The derived solution of the inverse problem made it possible to advance the studies to high energy regions by almost 2 orders of magnitude. (TTT)

2851 SEARCH FOR QUARKS WITH SINGLE AND FRACTIONAL CHARGES IN COSMIC RAYS AT THE ELEVATION OF 3200 M. Khrimyan, A. V.; Avakyan, V. V.; Khrimyan, G. V. Izv. Akad. Nauk SSSR, Ser. Fiz., 30: 1648-50(Oct. 1966). (In Russian).

The existence of quarks, (particles possessing a large mass and a fractional or integer charge) is under scrutiny; no cases involving fractional charges have been found as yet. Experiments were carried out on searching for such quarks with units and fractional charges, using the authors' previously described experimental method based on the measurement of the pulse, the free path, and the ionizing ability of the particles. The instrumentation included a five-layer gaseous proportional counter of the scintillation telescope. The quarks may be identified on the basis of their mass if the particle background (triton, ^3He, and ^4He for positive particles and antiproton for the negative ones) is low. Among the 3906 observations of heavy negative particles, 8 antiprotons were anticipated; one case among the heavy particles could not be explained by attribution to known particles. The probability of such an occurrence as a result of the fluctuation of ionization losses of known particles was calculated to be 10^{-4}, excluding the possibility that it involved a narrow particle beam which could not be resolved by the instrumentation used. (TTT)

2852 TEMPERATURE EFFECT OF THE MUON COMPONENT UNDERGROUND AND PION ATTENUATION LENGTH. Castagnoli, G. Cini; Dodero, M. A. (Univ., Turin). Nuovo Cim. (10), 51B: 525-34(Oct. 11, 1967).

The analysis of the temperature effects on the cosmic-ray muon component recorded continuously in the "Monte dei Cappuccini" Laboratory at 70 mwe, is used for obtaining the attenuation length of pions in air. In the energy range 30 to 60 GeV a mean value of $\lambda_\pi = (142 \pm 10) g/cm^2$ was found. The value of λ_π is considerably higher than the corresponding value for λ_p. Therefore the common assumption $\lambda_\pi \leq \lambda_p$ in the theories of the temperature effects on the muon component is not adequate at least up to 100 GeV. A calculation of the positive and negative temperature coefficients is carried out under the assumption $\lambda_\pi \neq \lambda_p$. (auth)

2853 MUON SPECTRA AND CHARGE RATIO AT SEA LEVEL AT A ZENITH ANGLE OF 45°. Allkofer, O. C.; Andresen, R. D. (Christian-Albrechts-Univ., Kiel). Nuovo Cim. (10), 51B: 329-40(Oct. 11, 1967).

The momentum distribution and charge ratio of the penetrating component of the cosmic radiation at sea level were determined over the range 0.2 to 20 GeV/c at a zenith angle of 45° in the eastern and western azimuths. A magnetic spectrograph was used for these measurements based on spark chamber technique for track location. (auth)

2854 STUDIES OF COSMIC RAYS RECORDED BY COSMOS-19 AND COSMOS-25 SATELLITES. Kuzhevskii, B. M.; Salimzibarov, R. B.; Sokolov, V. D.; Shafer, Yu. G. Kosm. Issled., 5: 772-81(Sept.-Oct. 1967). (In Russian).

Data on 11-year cosmic-ray modulations collected in Cosmos-19, Cosmos-25, and Explorer-7 satellites showed that cyclic intensity modulations, of nearly one-month period, take place near the solar activity minimum. The effective modulation area responsible for the variations is equal to ~10 a.e. Integral spectra for global intensity is of a power law spectrum with the indicator $\gamma = 0.58$ for $4 < R < 10$ BV. The Forbush reduction cases in the cosmic-ray intensity according to the nonscreened and screened counters are investigated. The intensity of cosmic rays during two September 1963 magnetic storms was reduced 9.2 and 8%, respectively. Abnormal fluxes of cosmic radiation recorded during the flight of Cosmos-25 in 1964 were interpreted as solar hard x radiation. (tr-auth)

2855 HEIGHT AND ZENITH ANGULAR DEPENDENCE OF THE ENERGY SPECTRUM OF COSMIC PARTICLES. Allkofer, O. C. (Christian-Albrechts-Univ., Kiel). Fortschr. Phys., 15: 113-96(1967). (In German).

The energy spectra of cosmic radiation are of twofold significance. First, they represent an important constant of cosmic radiation and, secondly, they can be used to obtain data on interaction processes which occur in the movement of the cosmic radiation through the atmosphere, by comparison of the spectra at various atmospheric heights. The current apparatus methods are sufficient to investigate energy spectra at sea level. They are, however, for the most part, too complicated in their structure and too large in their dimensions to be used for measurements at high altitudes or in rockets. Through new detector techniques it has become possible to so construct cosmic spectrometers for measurements at the highest altitudes. However, data on the height dependence of spectra in comparison to the spectra at sea level is very scanty. There are, however, results of spectral studies at various heights which do not always agree. The studies on cosmic spectra at various heights carried out in recent years are compiled. Inclination spectra and the positive excess are included. (101 references) (tr-auth)

2856 PRIMARY COSMIC RADIATION IN THE ENERGY REGION ABOVE 10^{14} eV. Truemper, J. (Christian-Albrechts-Univ., Kiel). Fortschr. Phys., 15: 197-268(1967). (In German).

Results that individual experiments have yielded with respect to the primary particle aspect and the total picture of primary radiation in air showers that can be obtained at present are surveyed. The structure of cosmic showers and the property of nuclear interactions at high energies are outlined. The characteristics of extrasolar cosmic radiation in the energy range below 10^{14} eV are described. The primary cosmic radiation in extensive air showers is discussed and the chemical composition in the cosmic shower range is considered. (132 references) (J.S.R.)

2857 FURTHER EVIDENCE FOR THE TWO-CENTER (FIREBALL) MODEL OF COSMIC-RAY JETS. Friedlander, E. M. (Inst. of Atomic Physics, Bucharest). Nuovo Cim. (10), 52A: 291-4(Nov. 1, 1967).

It is shown that the use of higher moments of the angular distribution allows independent estimation of both the relative velocity of the decaying bodies and the degree of anisotropy in the fireball rest frame. This method is applied to a relatively large sample of high-energy jets. From the results of this analysis it is found that the fireball model describes satisfactorily a much wider class of events than was hitherto suspected. Isotropy in the fireball rest system could be proved without preliminary selection of the events. (J.F.P.)

2858 PRODUCTION OF NEUTRONS BY COSMIC RADIATION. Korff, Serge A. (New York Univ., N. Y.). pp 427-40 of Natural Radiation Environment. Adams, John A. S.; Lowder, Wayne M. (eds.). Chicago, University of Chicago Press, 1964.

The production of neutrons by cosmic radiation is discussed in terms of the properties of primary cosmic radiation, neutron equilibrium in the atmosphere, and evaluation of the various measurements. (W.D.M.)

2859 SOLAR MODULATION OF PRIMARY COSMIC RAYS AS DEDUCED FROM NEUTRON MONITOR DATA. Bertsch, D. L.; Fody, S. A. (Washington Univ., St. Louis). J. Geophys. Res., 72: 5347-56(Nov. 1, 1967).

An empirical relation has been found that describes the rigidity and long-term time variations of the counting rates of neutron monitors at sea level. The formula is applicable for the period between the 1954–1955 and 1964–1965 solar minimums for stations with vertical threshold rigidities above 1.3 GV. The data of the Mt. Washington, Climax, and Mt. Norikura neutron monitors have been used to establish the relation. Through the use of this empirical relation and the available neutron monitor response functions, the relative fractional time variations of the differential rigidity spectra of primary cosmic rays have been derived for rigidities above 2.5 GV. The corresponding modulation of the integral spectra has been calculated on the assumption that the generally accepted quiet-time differential alpha spectrum is valid. The derived and the experimental fluxes have been shown to agree satisfactorily throughout the 1954–1965 solar cycle. (auth)

2860 CHARGE AND ENERGY SPECTRUM OF HEAVY NUCLEI DURING THE SOLAR MINIMUM, 1965. Durgaprasad, N.; Reames, D. V. (Goddard Space Flight Center, Greenbelt, Md.). Phys. Rev., 162: 1296-8(Oct. 25, 1967).

The differential energy spectra of H_1 ($Z \geq 20$) and H ($Z \geq 10$) nuclei were measured in a balloon flight at a time close to the solar minimum using a nuclear emulsion stack flown at an altitude of 2.7 g/cm^2 from Fort Churchill, Manitoba, Canada, on 30 June 1965. δ-ray density and residual range measurements on tracks, and measurements of change of δ-ray density with track length, were used to determine the charge and energy of the nuclei. The measured differential fluxes of H_1($Z \geq 20$) and H ($Z \geq 10$) nuclei are 0.0013 ± 0.0006 and 0.0045 ± 0.0010 particles/(m^2sr sec MeV per nucleon) in the energy range 300–500 MeV per nucleon and 0.0011 ± 0.0004 and 0.0049 ± 0.0008 particles/(m^2sr sec MeV per nucleon) in the energy range 500–800 MeV per nucleon. These results are in agreement with satellite and rocket measurements made in the similar energy range, and, when compared with low-energy measurements, indicate an energy spectrum of nuclei that is flatter than those observed during earlier years. (auth)

2861 LOW-ENERGY COSMIC-RAY COMPOSITION AND ENERGY SPECTRA MEASURED IN JUNE 1965. Reames, D. V.; Fichtel, C. E. (Goddard Space Flight Center, Greenbelt, Md.). Phys. Rev., 162: 1291-5(Oct. 25, 1967).

Sounding rockets carrying nuclear emulsions to study the composition and energy spectra of the low-energy cosmic rays were flown on 17 and 23 June 1965 from Fort Churchill, Canada. The results show that the intensity of the heavy nuclei ($Z \geq 3$) was about the same as that in July 1964 and below that measured by other observers in May and early June 1965, before the Forbush decrease on 15 June 1965. The helium-nucleus flux between 15 and 22 MeV/nucleon was found to be significantly lower on 17 June 1965 immediately after the Forbush decrease than on 23 June 1965. The charge spectrum indicates that in the region from 40 to 90 MeV/nucleon the ratio of light- to medium-nucleus fluxes is 0.19 ± 0.07, well below the value of 0.5 found at intermediate energies (200 to 400 MeV/nucleon), and that the carbon-to-oxygen ratio is about 1, rather than 1.6 as found at higher energies. A strong preference for even nuclei relative to odd is seen for charges 9 to 14 in the 60- to 180-MeV/nucleon range. (auth)

2862 COMPARISON OF THE FLUX OF COSMIC-RAY PARTICLES MEASURED IN SPACE TO THAT DEDUCED FROM BALLOON FLIGHTS USING IONIZATION CHAMBERS. Neher, H. V. (California Inst. of Tech., Pasadena); Anderson Hugh R. J. Geophys. Res., 72: 5515-17(Nov. 1, 1967).

Cosmic-ray flux data from the ion chamber and G–M tube experiment on Mariner-4 are compared with that calculated from

balloon-borne ionization chambers. Daily average values are plotted of omnidirectional flux and ionization rate from Mariner-4 measurements. (J.H.M.)

2863 LOW-ENERGY, SECONDARY ELECTRONS AT BALLOON ALTITUDES. Brunstein, K. A. (Univ. of Denver). J. Geophys. Res., 72: 5510-14(Nov. 1, 1967).

Electron data from measurements of a Sioux Falls balloon flight are plotted and analyzed, and an attempt is made to determine the origin of the electrons. IMP-A observations are also plotted and compared with the balloon flight data. (J.H.M.)

2864 SOLAR-CYCLE VARIATION IN THE MASS ABSORPTION COEFFICIENTS FOR THE CLIMAX AND CHICAGO NEUTRON MONITORS, 1953-1965. Forman, Miriam A. (Council for Scientific and Industrial Research, Pretoria. Potchefstroom Univ., South Africa). J. Geophys. Res., 72: 5572-5(Nov. 1, 1967).

Summaries are presented of mass absorption coefficients for the Climax neutron monitor, 1953–1965, and the Chicago neutron monitor, 1958–1965. Reports from similar stations on solar-cycle variations in mass absorption coefficients are discussed. (J.H.M.)

2865 RECENT ADVANCES IN COSMIC RAY RESEARCH. Proceedings of a Symposium at the Douglas Advanced Research Laboratories, Huntington Beach, California, April 4–6, 1966. Gauger, J.; Masley, A. J. (eds.). North Hollywood, Calif., Western Periodicals Co., 1966. 337p. (CONF-660445). DTIE.

Papers are presented on rigidity models and latitude surveys, solar and galactic cosmic radiation, auroral phenomena, and utilization of aircraft for research. Separate abstracts were prepared for the fifteen papers. (W.D.M.)

For abstracts of individual papers see: 2866–2878, 2913, and 2914.

2866 COSMIC RAYS AND THE GEOMAGNETIC FIELD. Elliot, H. (Imperial Coll. of Science and Tech., London). pp 1-18 of Recent Advances in Cosmic Ray Research. Gauger, J.; Masley, A. J. (eds.). North Hollywood, Calif., Western Periodicals Co., 1966.

From Symposium on Recent Advances in Cosmic Ray Research, Huntington Beach, Calif., Apr. 3–7, 1966. See CONF-660445.

The form of the primary cosmic-ray energy spectrum and the study of its time dependence have been the subject of a major research effort ever since work in this field began. An historical summary on the studies carried out is given. Topics covered are the primary cosmic-ray spectrum derived from latitude surveys and airborne latitude surveys of the secondary intensity. 22 references. (W.D.M.)

2867 COSMIC RAY CUTOFF RIGIDITY CALCULATIONS AND THEIR APPLICATION TO EXPERIMENTAL MEASUREMENTS. Shea, M. A.; Smart, Don F. (Air Force Cambridge Research Labs., Cambridge, Mass.). pp 19-54 of Recent Advances in Cosmic Ray Research. Gauger, J.; Masley, A. J. (eds.). North Hollywood, Calif., Western Periodicals Co., 1966.

From Symposium on Recent Advances in Cosmic Ray Research, Huntington Beach, Calif., Apr. 3–7, 1966. See CONF-660445.

Using sixth-degree simulations of the geomagnetic field, the cutoff rigidities of over 1000 locations on the Earth's surface were calculated by tracing the trajectories of cosmic-ray particles at rigidity intervals as small as 0.01 BV. These trajectory-derived cutoffs are applied to cosmic-ray intensity data and are shown to produce a more coherent ordering of the data than other methods. It is found that there is essentially no difference between the trajectory-derived cutoff rigities obtained using either 1955 or 1960 models of the geomagnetic field. The maximum cutoff rigidity equator is calculated in this manner, and the effect of nonzenith directions considered. The maximum vertical cutoff rigidity equator is compared with experimental observations and shown to describe the minimum cosmic-ray intensity equator. These trajectory-derived cutoff rigidities are correlated with the L parameter and the usefulness of this parameter in approximating cutoff rigidities is examined. A 5 by 15° world grid of trajectory-derived cutoff rigidities is being prepared and the preliminary data interpolated from this yet incomplete table is shown to be more accurate than are the presently available published tables of cutoff rigidities. (auth)

2868 EXPERIMENTAL EVALUATION OF VARIOUS RIGIDITY MODELS. Kenney, J. F. (Boeing Scientific Research Labs., Seattle); Gauger, J.; Shea, M. A.; Smart, D. F. pp 55-72 of Recent Advances in Cosmic Ray Research. Gauger, J.; Masley, A. J. (eds.). North Hollywood, Calif., Western Periodicals Co., 1966.

From Symposium on Recent Advances in Cosmic Ray Research, Huntington Beach, Calif., Apr. 3–7, 1966. See CONF-660445.

Atmospheric cosmic-ray fluxes have recently been measured over large portions of the globe on a series of flights of a jet aircraft. The measured fluxes have been plotted as a function of the vertical cutoff rigidity for several different models. The rigorous trajectory calculations of Shea et al. give good agreement with the counting rates. The Makino model also orders these data equally well, and therefore must be within a few percent of the value determined by rigorous orbit calculations taken over the portions of the globe covered in this survey. The other models are demonstrably worse, and a discussion of where these models are inadequate is given. Particular attention is paid to the use of the L parameter as a substitute for rigorous integration procedures. It is shown both experimentally and theoretically that the L parameter is not a good demographic parameter for galactic cosmic radiation at the lower latitudes, but should be sufficiently adequate at higher latitudes for most purposes. (auth)

2869 PRELIMINARY RESULTS OF COSMIC RAY SPECTRUM AND GEOMAGNETIC CUTOFF SURVEYS DURING SPRING 1966. D'Arcy, Raymond G. (Univ. of California, Livermore). pp 73-88 of Recent Advances in Cosmic Ray Research. Gauger, J.; Masley, A. J. (eds.). North Hollywood, Calif., Western Periodicals Co., 1966.

From Symposium on Recent Advances in Cosmic Ray Research, Huntington Beach, Calif., Apr. 3–7, 1966. See CONF-660445.

In February 1966 two of three AEC aircraft (the Los Alamos and Sandia C-135 aircraft) made a series of flights for cosmic-ray measurements. During this series of flights, the Los Alamos plane went from Puerto Rico south near the 60° geographic west longitude line past Buenos Aires to as far south as the tip of South America. Simultaneously, the Sandia airplane went at similar altitudes and close to a conjugate location north near the 60° geographic west longitude line. During the period of March through June, 1966, a series of flights over North America, Hawaii, and Alaska were made by the Lawrence Radiation Lab. C-135, with particular attention to longitudes 105°W and 155°W. A latitude survey from 65°N to 58°S latitude along a line of approximately 60°W longitude was completed with the two aircraft magnetically conjugate to each other. Instrumentation used in the planes is described and preliminary results are given. (W.D.M.)

2870 JAPANESE AIRBORNE COSMIC RAY EXPERIMENTS. Obayashi, T. (Kyoto Univ.). pp 89-97 of Recent Advances in Cosmic Ray Research. Gauger, J.; Masley, A. J. (eds.). North Hollywood, Calif., Western Periodicals Co., 1966.

From Symposium on Recent Advances in Cosmic Ray Research, Huntington Beach, Calif., Apr. 3–7, 1966. See CONF-660445.

To investigate the latitude variations of primary cosmic-ray intensity, airborne as well as ship-borne measurements using neutron monitors were carried out. The aircraft crossed the Pacific via San Francisco–Honolulu–Tokyo, at a cruising altitude of approximately 10,000 m. Two sets of counters were used for the airborne shower experiments. The shower-particle density was measured with a set of three Geiger-counter trays placed at the vertices of a triangle with a 3-m side and two trays located along the aircraft and separated by 16 meters. (W.D.M.)

2871 LOW ENERGY GALACTIC COSMIC RAYS. Balasubrahmanyan, V. K.; Hagge, D. E.; McDonald, F. B. (Goddard Space Flight Center, Greenbelt, Md.). pp 101-27 of Recent Advances in Cosmic Ray Research. Gauger, J.; Masley, A. J. (eds.). North Hollywood, Calif., Western Periodicals Co., 1966.

From Symposium on Recent Advances in Cosmic Ray Research, Huntington Beach, Calif., Apr. 3–7, 1966. See CONF-660445.

This paper is a report on a review of experiments carried out on the IMP and OGO satellites as well as on Skyhook balloons by the Goddard cosmic-ray group. The main objectives were to study the galactic cosmic rays, especially when the modulation effects were least, and also to try to study the modulation mechanism itself. This is necessary to correct for residual modulation and to study the nature of the interplanetary processes causing the observed time variations. (W.D.M.)

2872 COMPOSITION AND SPECTRA OF CHARGED PARTICLES OF SOLAR AND COSMIC ORIGIN MEASURED ON SATELLITES. Comstock, G.; Fan, C. Y.; Gloeckler, G.; Simpson, J. A. (Univ. of Chicago). pp 129-45 of Recent Advances in Cosmic Ray Research. Gauger, J.; Masley, A. J. (eds.). North Hollywood, Calif., Western Periodicals Co., 1966.

From Symposium on Recent Advances in Cosmic Ray Research, Huntington Beach, Calif., Apr. 3–7, 1966. See CONF-660445.

This paper consists of two parts: (1) abundances and energy spectra for nuclei of galactic origin above 20 MeV per nucleon; and (2) protons and helium nuclei with interplanetary magnetic regions which co-rotate with the Sun. These results were obtained from experiments on OGO-I and IMP-I satellites. (auth)

2873 INTERPLANETARY DIFFUSION AND COSMIC RAY MODULATION. Krimigis, S. M. (Univ. of Iowa, Iowa City). pp 147-70 of Recent Advances in Cosmic Ray Research. Gauger, J.; Masley, A. J. (eds.). North Hollywood, Calif., Western Periodicals Co., 1966.

From Symposium on Recent Advances in Cosmic Ray Research, Huntington Beach, Calif., Apr. 3–7, 1966. See CONF-660445.

In the last few years, the importance of diffusion in the interplanetary propagation of solar particles has been recognized and various models have been proposed in order to explain the experimentally observed intensity–time profiles of solar particle events. Particularly successful in accounting for both the increase and the decay phase in a particle event has been the model where the assumption of a position-dependent diffusion coefficient is made. It is the purpose of this paper to briefly review this model, discuss its limitations by showing some new experimental results obtained with Mariner IV, and finally, to examine the implications that diffusive propagation has for the modulation of cosmic rays. (W.D.M.)

2874 OBSERVATIONS ON THE PROPAGATION OF SOLAR FLARE ELECTRONS IN INTERPLANETARY SPACE. Anderson, K. A.; Lin, R. P. (Univ. of California, Berkeley). pp 171-8 of Recent Advances in Cosmic Ray Research. Gauger, J.; Masley, A. J. (eds.). North Hollywood, Calif., Western Periodicals Co., 1966.

From Symposium on Recent Advances in Cosmic Ray Research, Huntington Beach, Calif., Apr. 3–7, 1966. See CONF-660445.

The purpose of this paper is to report examples of solar flare electron events and to show that the propagation of electrons in the neighborhood of the Earth is highly anisotropic in two respects. The observations were made from the first and third IMP satellites during 1964, 1965, and 1966. The experiment utilized two G–M tubes and an ionization chamber. (W.D.M.)

2875 ENTRY OF SOLAR PROTONS AND ALPHA-PARTICLES INTO POLAR CAP ATMOSPHERE. Obayashi, T.; Hakura, Y. (Kyoto Univ.). pp 181-9 of Recent Advances in Cosmic Ray Research. Gauger, J.; Masley, A. J. (eds.). North Hollywood, Calif., Western Periodicals Co., 1966.

From Symposium on Recent Advances in Cosmic Ray Research, Huntington Beach, Calif., Apr. 3–7, 1966. See CONF-660445.

The initial phase of PCA consists of at least three characteristic stages which occur successively at different zones in the polar cap, the result being suggestive of composition-dependent differential precipitation of solar particles. Theoretical consideration is given to identifying the solar cosmic-ray composition (protons and alpha particles) entering the geomagnetic field. (W.D.M.)

2876 CHARACTERISTICS OF SOLAR COSMIC RAY EVENTS. SOLAR MINIMUM VERSUS SOLAR MAXIMUM. Masley, A. J.; Goedeke, A. D. (Douglas Missile and Space Systems Div., Newport Beach, Calif.). pp 191-9 of Recent Advances in Cosmic Ray Research. Gauger, J.; Masley, A. J. (eds.). North Hollywood, Calif., Western Periodicals Co., 1966.

From Symposium on Recent Advances in Cosmic Ray Research, Huntington Beach, Calif., Apr. 3–7, 1966. See CONF-660445.

Some 50 solar cosmic-ray events have been observed since early 1962, through solar minimum, to early 1966. The peak intensities for these events range from less than 1 p/cm^2-sec-ster to 7000 p/cm^2-sec-ster for greater than 0.5-MeV protons. About 15 of the events were flare-associated, five are questionable, and thirty are probably not flare-associated. The events near solar minimum are, in general, of lower intensity and lower energy than the solar maximum events. (W.D.M.)

2877 THEORETICAL STUDIES OF SOLAR COSMIC RAY: IONOSPHERE INTERACTIONS. Adams, G. W.; Masley, A. J. (Douglas Missile and Space Systems Div., Newport Beach, Calif.). pp 201-26 of Recent Advances in Cosmic Ray Research. Gauger, J.; Masley, A. J. (eds.). North Hollywood, Calif., Western Periodicals Co., 1966.

From Symposium on Recent Advances in Cosmic Ray Research, Huntington Beach, Calif., Apr. 3–7, 1966. See CONF-660445.

A survey is presented of theoretical and numerical studies of the interactions of solar cosmic rays with the Earth's ionosphere and the resultant absorption of cosmic radio noise. The physical processes and the methods of calculation are given, and several examples of absorption calculated from satellite data are compared to riometer measurements. The intensity, energy, and particle-species sensitivities of riometers are discussed, along with a detailed discussion of the contribution made to the absorption by α particles, which is found to be small for solar cosmic-ray events observed in the polar caps. The multifrequency riometer technique is discussed from the standpoint of ground-based determinations of solar cosmic-ray energy spectra, and the first spectra so determined are shown and compared to satellite measurements. (auth)

2878 RESEARCH ACTIVITIES OF THE NASA CV-990 AIRCRAFT DURING THE PAST YEAR. Bader, Michel (Ames Research Center, Moffett Field, Calif.). pp 313-25 of Recent Advances in Cosmic Ray Research. Gauger, J.; Masley, A. J. (eds.). North Hollywood, Calif., Western Periodicals Co., 1966.

From Symposium on Recent Advances in Cosmic Ray Research, Huntington Beach, Calif., Apr. 3–7, 1966. See CONF-660445.

The various flights of the NASA CV-990 aircraft are described, and a general discussion is presented on what the airplane is capable of doing in the way of space sciences research. (W.D.M.)

2879 OBSERVATIONS OF HIGH-ENERGY GAMMA RAYS AT THE TOP OF THE ATOMSPHERE. Share, Gerald Harvey. Rochester, N. Y., Univ. of Rochester, 1967. 129p.

Thesis.

Observations of γ rays with energies greater than about 50 MeV were made in the upper atmosphere with a scintillation-Cherenkov telescope at geomagnetic latitudes 41°N and 55°N. Calibration of the telescope was carried out with a tagged γ-ray beam; the results were confirmed by a Monte Carlo calculation. The flux of secondary γ radiation near the top of the atmosphere was also computed, making possible a prediction of the telescope's response to this flux. The prediction agreed well with flight data from a well-guarded class of events, in which both members of the electron pairs were detected. Estimates of the extraterrestrial diffuse γ-ray flux were obtained from extrapolation of the data to the top of the atmosphere. No positive identification of a diffuse cosmic γ-ray flux was made. The primary flux, arising from decay of neutral pions produced in high-energy collisions, was estimated to be $(3.6 \pm 13) \times 10^{-4}$ γ(cm^2 ster sec)$^{-1}$. Alternatively, the flux arising from inverse Compton collisions of electrons with starlight and blackbody photons was estimated to be $(4.3 \pm 16) \times 10^{-4}$ γ(cm^2 ster sec)$^{-1}$. A 24-hour scan of the celestial sphere between declinations of +4 and +60° was made in search of discrete sources. No statistically significant sources were found, and upper limits (99.7% confidence level) down to 8×10^{-4} γ(cm^2 sec)$^{-1}$ were established for sources emitting γ rays with a π^0-decay spectrum. (Disser. Abstr.)

Direct Energy Conversion

Refer also to abstracts 3040 and 3041.

2880 (IAE–1160) FIZICHESKIE PROTSESSY V PLAZMENNOM DIODE. (Sbornik). (Physical Processes in Plasma Diode. (Compilation of Articles)). (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow. Institut Atomnoi Energii). 1966. 48p. (In Russian). Dep.

Four articles on physical processes in a plasma diode were compiled. Individual abstracts were prepared for each. (J.S.R.)

For abstracts of individual sections see: 2881, 2882, 3040, and 3041.

2881 (IAE–1160, pp 3-14) PRIBLIZHENNAYA DIFFUZIONNAYA TEORIYA TERMOEMISSIONNYKH PREOBRAZOVATLEI. (Approximate Diffusion Theory of Thermoemission Converters). Nastoyashchii, A. F. (In Russian).

A diffusion description is given of thermoemission converters. By neglect of the processes of thermodiffusion a simple analytical formula for volt–ampere characteristics is obtained. The expression obtained describes the dependence of the output parameters of the converter on the pressure of the cesium vapor, cathode emission, and anode temperature. The structure of the plasma gap in the model examined was taken into consideration by means of the appropriate averaging of the mobility of the electrons and ions in the gap; this averaging is done only for the simple case, when the mobility of the electrons does not depend on their temperature. In the more general cases of averaging more precise details must be taken into consideration, such as the initial heating of the electrons. The pertinent expressions must be solved by numerical methods. The expressions obtained accurately and quantitatively describe such changes of the output parameters during transition to Knudsen regime. It is shown that the opti-

mum saturation current with respect to the pressure of the cesium vapor is attained in the diffusion regime or in the regime intermediate between the diffusion and Knudsen regimes. (tr-auth)

2882 (IAE-1160, pp 43-8) IONIZATSIONNOE RAVNOVESIE V PLAZMENNOM DIODE. (Ionization Equilibrium in Plasma Diode). Kosyrev, F. K.; Nactoyashchii, A. F. (In Russian).

The investigation of the ionization equilibrium in plasma layers supported by electrical currents (plasma diode, thermoemission converters, etc.), is reported. It is shown that, during establishment of the local ionization equilibrium in the plasma, the spatial distribution of the concentration of the electrons and their temperature must satisfy some simple laws which were confirmed experimentally by means of cesium plasma. (tr-auth)

2883 (AD-655362, pp 1-13) APPROXIMATE CALCULATION OF A CONDUCTIVE MHD-GENERATOR WITH USE OF THE CONCEPT OF ENTROPY. Munshtukov, D. A. Translated from Vop. Magn. Gidrodin., Akad. Nauk Latv. SSR, Inst. Fiz., 3rd, 5-8 (1963).

A brief review dealing with the calculation of linear dc magnetohydrodynamic generators is given, along with a critique, after which the author proposes his own calculation method. The new method is said to expand somewhat the possibilities of a qualitative estimate of the energy conversion processes, since no constraints are imposed on the constancy of any parameter along the length of the flow-through part of the magnetohydrodynamic generator. The calculation is valid for unidimensional stationary motion of the electrically conductive gas when the magnetic Reynolds numbers are small and when both heat flows and end effects are absent. A further assumption is that the magnetic permeability and dielectric constant of the gas under consideration approximate the corresponding values of the vacuum and that the gas is governed by the equation for the state of an ideal gas ($P/\rho = RT$). (ATD)

2884 (CEA-tr-R-1902) ETUDE DES TUYERES RADIALES SUPERSONIQUES POUR LES CONVERTISSEURS MHD. (Study of Supersonic Radial Nozzles for MHD Converters). Tikhonov, B. A.; Shevchenko, V. R. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow, Institut Atomnoi Energii). Translated into French from report IAE-1347. 19p. (In French). Dep. CFSTI. JCL $1.60 fs, $0.80 mf.

The results of studies on the dynamics of gases in supersonic radial nozzles were reported. The experimental data on the effects of the principal geometric dimensions of the radial nozzle on its gas dynamic characteristics were given. Suggestions were made on the construction of radial nozzles with a uniform field of flow at the output. (tr-auth)

2885 ENERGY SYSTEMS. THE MHD COMBINATION. Young, W. E. (Westinghouse Research Labs., Pittsburgh); Way, S.; Tsu, T. C.; Hoover, D. Q.; Cochran, N. P. Mech. Eng., 89: No. 11, 49-57(Nov. 1967).

The possibilities of using a magnetohydrodynamic generator as the first step in power generation, the "topping plant," combined with a conventional steam "bottoming plant," are explored. Hot gas from the MHD generator gives up its heat to boilers (heat exchangers) serving the conventional steam plant. Decisions to be made include the kind of fuel to be used; the kind of "seeding" and the method of reclaiming the seed from the flue for reuse; the design of the combustor to withstand the extreme heat; and the relative size of the topping and bottoming plants for ideal operation. All these factors have been brought together into a tentative combination for actual plant design. (auth)

2886 UNSTEADY FLOW OF A CONDUCTING LIQUID IN THE CHANNEL OF AN MHD GENERATOR AT CONSTANT FLOW, WITH ALLOWANCE FOR THE INFLUENCE OF THE SIDE WALLS. Ryabinin, A. G.; Khozhainov, A. I. Zh. Prikl. Mekh. Tekh. Fiz., No. 2, 31-4(Mar.-Apr. 1967). (In Russian).

In view of the fact that earlier investigations of the problem were made under the assumption that the distance between side walls is infinite, corresponding to low magnetic Reynolds numbers, the authors obtain a solution for the flow of a viscous incompressible conducting liquid in a flat MHD channel of finite width and arbitrary load coefficient. The magnetic Reynolds number is assumed small. This problem corresponds to the case of control of the power of the MHD generator by varying the magnetic induction. The system of magnetohydrodynamic equations is simplified by assuming that the width of the channel is much larger than the height. The approximations assumed during the course of the solution are based on the authors' earlier experimental results (Zh. Tekh. Fiz., 32: No. 1(1962)). The solution makes it possible to calculate the variation of the pressure loss in the MHD channel when the magnetic field is turned on and calculate the change in power occurring when the magnetic induction is changed. The latter is useful for control purposes. It is shown that just as in the case of an infinite channel, it is possible to reduce the system of initial magnetohydrodynamic equations to a single equation for the velocity. (ATD)

2887 UNSTEADY FLOW OF AN ELECTRICALLY CONDUCTING GAS IN CROSSED ELECTRIC AND MAGNETIC FIELDS. Genkin, A. L.; Kudryashova, L. A Zh. Prikl. Mekh. Tekh. Fiz., No. 2, 41-4(Mar.-Apr. 1967). (In Russian).

An analysis is made of the one-dimensional unsteady motion, of a nonviscous non-heat-conducting and electrically conducting gas, characterized by a small magnetic Reynolds number, in a constant cross section channel of a magnetohydrodynamic energy converter. The solution is obtained by transforming the differential equations into a system of integral equations which can be solved exactly if the electric conductivity of the gas is constant. A numerical example is presented for a simple case and shows that to obtain a linear variation of the voltage it is necessary to have an essentially nonlinear variation of the external load. (ATD)

2888 COMPARISON OF MHD INDUCTION GENERATOR ANALYSES. Wang, T. C. (TRW Systems, Redondo Beach, Calif.); Dudzinsky, S. J. AIAA (Amer. Inst. Aeronaut. Astronaut.) J., 5: 2059-60(Nov. 1967).

A comparison was made of three different analyses of a common model of the flat-channel, linear MHD induction generator. An outline is given of each approach, and the resulting expressions for the gross power outputs are compared. (M.O.W.)

2889 METHOD OF AND APPARATUS FOR ALTERNATING CURRENT TO DIRECT CURRENT CONVERSION UTILIZING A LIQUID METAL CIRCULATION LOOP. (to Nihon Genshiryoku Kenkyu-Sho). British Patenf 1,085,731. Oct. 4, 1967, Priority date Apr. 2, 1964, Japan.

The design and performance of an ac-to-dc converter utilizing a liquid metal circulation loop is presented. The liquid metal is circulated by an ac pump, and an MHD generater converts the mechanical work to dc power. A cooling unit is utilized to control the temperature of the liquid metal. (W.H.K.)

Fluid Physics

Refer also to abstracts 2883, 2886, and 2887.

2890 (AD-655362) QUESTIONS OF MAGNETOHYDRODYNAMICS III (SELECTED ARTICLES). Translation of Vop. Magn. Gidrodin., Akad. Nauk Latv. SSR, Inst. Fiz., 3rd, 5-8; 395-405(1963). 19p. (FTD-MT-65-293; TT-7500248-249). CFSTI.

Separate abstracts were prepared for the two articles contained. (W.D.M.)

For abstracts of individual papers see: 2883 and 2891.

2891 (AD-655362, pp 15-19) CONCERNING A DIFFERENT APPROACH TO DETERMINATION OF MAGNETIC REYNOLDS NUMBER AND BOUNDEDNESS OF THE ONE-DIMENSIONAL APPROXIMATION WITH RESPECT TO Re_m DURING FLOW OF A CONDUCTING GAS. Popov, G. A.; Tikhonov, V. B. Translated from Vop. Magn. Gidrodin., Akad. Nauk Latv. SSR, Inst. Fiz., 3rd, 395-405(1963).

Several definitions of Re_m are analyzed and it is shown that for a turbulent flow it is definable as the ratio of magnetic field "carry-off" (by the flow) to the rate of magnetic field diffusion into the flow. Definitions given by various authors in relation to laminar flows are critized: specifically, that Re_m is the ratio of induced current to current required to develop a given external magnetic field at a single coil turn, that it is the ratio of the plasma current-induced magnetic field to an applied external magnetic field, and that it characterizes the ratio of inertial forces to electromagnetic body forces. The analysis indicates the limited scope imposed by such definitions. (ATD)

2892 NONMECHANICAL TORQUE-DRIVEN FLOW OF A FERROMAGNETIC FLUID BY AN ELECTROMAGNETIC FIELD. Moskowitz, R.; Rosensweig, R. E. (Avco Space Systems Div., Lowell, Mass.). Appl. Phys. Lett., 11: 301-3(Nov. 15, 1967).

Flows of ferromagnetic fluids (colloidal suspensions) are obtained by coupling to the suspended single-domain particles with a rotating magnetic field. It is shown that very high rotation rates are possible by this technique. Nonmechanical torque-driven flows represent a hitherto unexplored area in the physics of fluids that has interesting potential technological application. A ferromagnetic pump based upon the present principle could be of great value in fluidic systems and open up new applications in space, ocean, biological, and other environments. (auth)

2893 ON THE ONSET OF INSTABILITY BY OSCILLATORY MODES IN HYDROMAGNETIC COUETTE FLOW. Chang, T. S.; Sartory, W. K. (Oak Ridge National Lab., Tenn.). Proc. Roy. Soc. (London), Ser. A, 301: 451-71(Nov. 7, 1967).

The transition of the onset of instability from stationary modes to oscillatory modes for an incompressible, conducting Couette flow between two coaxial, perfectly conducting, non-permeable, rotating cylinders under the influence of an axially applied magnetic field is considered. Results for three cases are reported. These pertain to flow between (1) a rotating inner wall with a stationary outer wall, (2) counterrotating walls, and (3) corotating walls. It is found that, for high values of the Hartmann number, there may exist some range of convective wavenumbers for which neither of the two lowest modes of axisymmetrical disturbances will become stationary. Within this range, the neutral stability curve is determined by a complex-conjugate pair of oscillatory axisymmetrical modes of equal stability. The oscillatory modes may, in fact, become more critical than the stationary modes. It is demonstrated that the approximation of replacing the angular speed by its average value, combined with the assumption of a narrow gap between the cylindrical walls, eliminates the oscillatory axisymmetrical modes. (auth)

2894 IMPULSIVELY STARTED STAGNATION POINT FLOW IN MAGNETOHYDRODYNAMICS. Barrett, K. E. (Univ. of Liverpool). Quart. J. Mech. Appl. Math., 20: 509-16(1967).

The motion generated by impulsively starting a dipole-magnetized, perfectly conducting cylinder in a conducting, viscous, incompressible fluid, to which a uniform magnetic field is applied, is discussed. Attention is restricted to the case of aligned flows for which there is no normal field at the cylinder surface and for which the magnetic fields are large. It is shown that near the front and rear stagnation points reverse flow sets in simultaneously and symmetrically. It is also shown that the equations governing steady flow near the stagnation points have no acceptable solution. (auth) (UK)

2895 SMALL HYDROMAGNETIC OSCILLATIONS OF A TWO-DIMENSIONAL CAVITY. Burghes, David N. (Univ. of Sheffield, Eng.). Proc. London Math. Soc., 17: 669-82(1967).

Small oscillations of a two-dimensional cavity in a fluid of infinite electrical conductivity are considered. Two models are formulated. In the first, the cavity surrounds a finite number of line currents; the fluid is free of magnetic field, and is at uniform pressure. The cavity in the second model is due to a finite number of line currents inside the cavity and a uniform magnetic field outside; material of infinite conductivity is trapped between the internal and external magnetic fields. Integral expressions for the magnetic potential energy are found when the system is subjected to a small general displacement. For the physical models formulated the kinetic energy may be found, and Lagrange's equations can then be used to find the normal modes of oscillation. (auth)

2896 OSCILLATIONS OF A CAPILLARY JET OF INFINITE ELECTRICAL CONDUCTIVITY IN THE PRESENCE OF DISSIPATIVE FORCES AND A UNIFORM AXIAL MAGNETIC FIELD. Srivastava, K. M.; Kushwaha, R. S. (Univ. of Jodhpur, India). Nuovo Cim. (10), 51B: 535-46(Oct. 11, 1967).

The method of normal-mode analysis is applied to study the oscillations of a capillary jet for nonaxisymmetric perturbations in the presence of a uniform axial magnetic field when viscous forces are present. It is assumed that the liquid is infinitely conducting. It is found that the damping constants are smaller than those for the nonviscous case. In particular, the limiting case of high viscosity has been discussed and the damping constant for m = 1 has been calculated. (auth)

2897 THE INFLUENCE OF MAGNETIC REYNOLDS NUMBER ON THE CHARACTERISTICS OF MAGNETOHYDRODYNAMIC FLOW OF VARYING PARAMETERS. Bertinov, A. I.; But, D. A. Izv. Akad. Nauk SSSR, Energ. Transp., No. 4, 57-66 (July-Aug. 1967). (In Russian).

The linear magnetohydrodynamic flow with use of the Faraday effect with arbitrary values of the magnetic Reynolds number R_m was examined. The effect of the variation of the electric conductivity and gas velocity on the flow characteristics was investigated It is shown that increase of R_m leads to a decrease of the total transverse magnetic flux in the channel. (tr-auth)

2898 DEGENERATION OF MAGNETOHYDRODYNAMIC MODES IN A COAXIAL CHANNEL WITH A HELICAL FIELD. Infeld, E. (Inst. of Nuclear Research, Warsaw). Phys. Fluids, 10: 2374-6(Nov. 1967).

The effect of a rectilinear current on Alfvén waves in a bounded medium is investigated. An infinite spectrum of frequencies corresponds to each Alfvén frequency obtained without the current. Therefore the I = 0 case is considered as degenerate since eigenfrequencies tend to the Alfvén frequency in this limit. A radial component of the disturbed field will always be present, even though none need be present for the current-free case. This component is a discontinuous function of the current (discontinuous at zero). A formula connecting the radial and azimuthal components of the field is obtained. This formula carries through when the $I \to 0$ limit is taken. For the I = 0 case the azimuthal and radial fields are completely unconnected, hence the discontinuity. In particular the azimuthal component of the magnetic field will vanish on the boundaries for all finite currents and in the $I \to 0$ limit, even though this is not true of the I = 0 case. The boundary conditions on the azimuthal component of the field are therefore seen to be discontinuous. (auth)

2899 MAGNETOHYDRODYNAMIC GRAVITY: CAPILLARY WAVES IN A LIQUID FILM. Lu, Pau-Chang; Sarma, G. S. R. (Case Inst. of Tech., Cleveland). Phys. Fluids, 10: 2339-44 (Nov. 1967).

The influence of a transverse magnetic field on the Kapitza capillary wave traveling down the surface of a falling, conducting liquid film is investigated. It is shown that, for small magnetic Reynolds numbers the range of admissible dimensionless celerity becomes narrower as the Hartmann number increases. When the Hartmann number reaches 4.63 there is but one single admissible wave celerity (1.43). With still stronger field strength, a traveling wave is no longer possible within the linear scheme employed. (auth)

2900 TURBULENT MERCURY JET. Hoult, David P. (Massachusetts Inst. of Tech., Cambridge). Phys. Fluids, 10: 2345-50(Nov. 1967).

Measurements of the mean velocity profiles of a free turbulent mercury jet in the presence of an axial magnetic field, with Reynolds numbers between 1×10^3 and 6×10^3, are reported. The Hartmann number, based on nozzle conditions varied from zero to 40. It is found that the eddy viscosity divided by the square root of the kinematic momentum has a sharp maxima as a function of (Reynolds number)$^{-1}$. A simple model which is consistent with the data is developed. The model suggests that, (1) the jet, although self-similar, has a rate of energy dissipation which depends on phenomena occurring at the nozzle. (2) the maxima in eddy viscosity are caused by the excitation of a helical instability near the nozzle. (auth)

2901 NONSTEADY FLOW OF A CONDUCTING LIQUID IN A SUDDENLY SHORT-CIRCUITED MHD GENERATOR. Khozhainov, A. I. Zh. Tekh. Fiz., 37: 1543-5(Aug. 1967). (In Russian).

The transformation of Grinberg (Zh. Tekh. Fiz., 33: 1384(1963)) was used to calculate the transient in the laminar flow of the conducting liquid in the channel of a magnetohydrodynamic generator due to the increase in the evolution of Joule heat following sudden short circuiting of the generator. The channel is assumed to have a rectangular cross section and to be much wider in the direction in which the current flows than in the direction of the magnetic field. The velocity of the liquid for the case of low magnetic Reynolds number and arbitrary time dependences of the kinematic viscosity, the dynamic viscosity, the conductivity, and the pressure gradient is given in the form of an infinite series, the terms of which involve quadratures. The quadratures are performed and the result is given as a doubly infinite series for the case when the pressure gradient and the ratio of the conductivity to the dynamic viscosity are constant and the kinematic viscosity changes according to a certain exponential-type law. (ATD)

2902 STABILITY OF HYDROMAGNETIC FLOWS. III. Arora, Kasturi L. (Panjab Engineering Coll., Chandigarh, India). J. Math. Anal. Appl., 19: 526-42(Sept. 1967).

A study is made of the stability of hydromagnetic flows in an infinitely long cylindrical pipe of an arbitrary smooth cross-section with an applied radial magnetic field. Fundamental equations and solutions are included in the study. (J.H.M.)

2903 FLOW AND HEAT-TRANSFER PHENOMENA OF PLASMA ARCS MAGNETICALLY BALANCED IN A CROSS FLOW. Roman, Ward C. (Aerospace Research Labs., Wright-Patterson AFB, Ohio). Res. Rev. (Office Aerosp. Res.), 6, No. 9, 1-18(Sept. 1967).

Results are presented of a study on a vertical plasma-arc column of 200 to 400 amperes, which was balanced magnetically in an atmospheric-pressure transverse air stream at velocities up to 60 fps. Measurements were made of the dimensions, enthalpy, heat flux, and turbulence of the wake. The arc cross section was found to change from a circular shape to an elliptical one with the major axis perpendicular to the flow. The arc column behaved like a solid aerodynamic drag body, impervious to the gas flow. The drag coefficients were in close agreement with those of solid cylinders. The velocity profile behind the arc column was measured; vortex shedding and turbulence were observed. The additional power required for the arc as compared to the no-flow

case was transferred almost completely to the gas flow, and the Nusselt number vs Reynolds number relationship is shown. The analogy with a heated solid cylinder is pointed out. (D.L.C.)

2904 ELECTRICAL CONDUCTIVITY OF HIGH-VOID-FRACTION TWO-PHASE FLOW IN AN MHD GENERATOR. II. ANALYSIS. Sense, Karl A. (TRW Systems, Redondo Beach, Calif.). AIAA (Amer. Inst. Aeronaut. Astronaut.) J., 5: 3097-9(Nov. 1967).

Theoretical results of the conductivity of high-void-fraction two-phase flow in MHD generators are described and compared with experimental ones. (M.O.W.)

2905 ELECTRICAL CONDUCTIVITY OF HIGH-VOID-FRACTION TWO-PHASE FLOW IN AN MHD GENERATOR. I. EXPERIMENT. Gelb, G. H.; Sense, K. A.; Zivi, S. M.; Neal, L. G. (TRW Systems, Redondo Beach, Calif.). AIAA (Amer. Inst. Aeronaut. Astronaut.) J., 5: 2094-7(Nov. 1967).

An experimental study was made to determine the effective electric conductivity of two-phase flow in a magnetic field. The experimental facility and measurement technique are described. (M.O.W.)

2906 FLOW OF A CONDUCTING LIQUID IN AN ANNULAR GAP: A RESTRICTED NONEXISTENCE PROOF. Schweitzer, S.; Cohen, I. M. (Univ. of Pennsylvania, Philadelphia). AIAA (Amer Inst. Aeronaut. Astronaut.) J., 5: 2066-8(Nov. 1967).

The problem of a liquid conductor confined between two concentric cylindrical electrodes is considered theoretically. The liquid metal is electromagnetically accelerated by the Lorentz force in the circumferential direction created when a current is passed between the two electrodes, and an axial magnetic field is applied. (M.O.W.)

2907 EIGHTH SYMPOSIUM ON ENGINEERING ASPECTS OF MAGNETOHYDRODYNAMICS, STANFORD UNIVERSITY, STANFORD, CALIFORNIA, MARCH 28-30, 1967. [Stanford, Calif., Stanford University Press, 1967]. 163p. (CONF-670323).

Twelve papers are presented on research and development in engineering magnetohydrodynamics. Forty abstracts are also included of the ten-minute presentations that deal primarily with work in progress on various engineering aspects of magnetohydrodynamics. Principal topic areas are: liquid metal MHD generators, combustion MHD generators, magnetofluidmechanics and reentry problems, nonequilibrium MHD power generation and stability problems, plasma diagnostics and properties, gas discharges, electrogasdynamic energy conversion, and engineering facilities and components. (J.H.M.)

2908 TURBULENCE SUPPRESSION IN MAGNETOHYDRODYNAMIC FLOWS. Olin, John George. Stanford, Calif., Stanford Univ., 1966. 169p.

Thesis.

The effect of the suppression of turbulent fluctuations in turbulent magnetohydrodynamic flows was investigated experimentally and theoretically. The experimental work consisted of the measurement of the change in velocity profiles in a quasi-fully developed channel flow due to an imposed, transverse magnetic field of $B_0 = 26.5$ kilogauss. The velocity profiles were measured in a plane perpendicular to the imposed magnetic field with a special cooled Pitot tube. A theoretical model based on Prandtl's mixing-length theory was developed to give simple, physical insight into the mechanism of the suppression of turbulent fluctuations by a magnetic field. The analysis revealed that fluctuating currents, $\vec{j}'$, are created in such a way that local $\vec{j}' \times \vec{B}_0$ body forces acting on the turbulent fluid lumps oppose the motion of the lumps. Newton's law for particle motion was then written for a typical lump. The solution of the resulting differential equation revealed that the motion of the lump transverse to the imposed magnetic field was exponentially damped by the magnetic field. An expression for the local, theoretical damping ratio was derived and compared with the corresponding experimental ratio. The local comparison showed some disagreement but also showed that average (over the spatial coordinate) values of the theoretical and experimental damping ratios could be compared favorably. This investigation reaffirmed the idea that turbulence suppression tends to "laminarize" velocity profiles, which in turn has the outgrowths of reducing the Reynolds stress and the friction factor. The reasonable comparison in the mean between the theory and the experiment indicated that in assessing the mean effect of turbulence suppression on the Reynolds stress, the mean damping parameter, M_m^2/R_m, is useful for order-of-magnitude estimates, and the mean, theoretical damping ratio might be useful for more refined estimates. (TSS) (Disser. Abstr.)

2909 STEADY LAMINAR COMPRESSIBLE MAGNETO-FLUIDDYNAMIC GAS FLOWS IN CHANNELS. Harstad, Kenneth Gunder. Pasadena, Calif., California Inst. of Tech., 1967. 115p.

Thesis.

Numerical computations are carried out for the core flow of subsonic MFD generator channels with a large length-to-height ratio and fine electrode segmentation. The working fluid is taken as potassium seeded argon. Variable transport properties and radiation effects are considered. It is shown that transverse variations in fluid properties are very important in Faraday generators; a one-dimensional analysis of the flow is not adequate. Axial currents in nonequilibrium flows can be kept low if the right value of the Hall parameter can be obtained; this also depends critically on the Mach number and load parameter. Mach numbers much less than one and high load parameters are to be avoided. Attainment of very large Hall parameters and fields cannot be expected. (Disser. Abstr.)

2910 THEORETICAL ASPECTS OF BLUNT-BODY MAGNETOAERODYNAMICS. Porter, Robert William. Evanston, Ill., Northwestern Univ., 1966. 222p.

Thesis.

Theoretical aspects of supersonic magnetoaerodynamic flow about a blunt body with self-contained magnetic field source are presented. The effect was studied for a hemisphere nose containing a dipole field source with body and magnetic axis at zero angle-of-attack. Theoretical predictions of the alteration of magnetoaerodynamic coefficients and of the flow field are presented for a range of parameters appropriate for possible application to planetary entry flight control and laboratory simulation. Emphasis was on determining the principal contributing effects for continuum, aerodynamic-like flows. After a general introductory to flight magnetohydrodynamics and appropriate literature survey, flight and laboratory regimes were delineated and compared. A mathematical model for constant property flow was developed and the equations were nondimensionalized in terms of parameter groups. Estimates of the expected range of parameters are presented. The equations were reduced for the stagnation region where the principal effect and local similarity occur. The resulting two point boundary value problem with undetermined boundary point was solved analytically for simple degenerate cases and numerically for more complex combinations of the parameters. The numerical techniques are discussed. It was found that the shock density ratio and magnetic interaction parameter are of principal importance. Viscous effects are also important for low-density laboratory flows. Results are presented which demonstrate these effects and the influence of magnetic field distortion and the Hall effect. Comparison with experiment and new avenues for theory are discussed. (Disser. Abstr.)

2911 THE LINEARIZED MAGNETOHYDRODYNAMIC FLOW PAST A SEMI-INFINITE FLAT PLATE IN THE PRESENCE OF A TRANSVERSE MAGNETIC FIELD. Hector, David Lawrence. Evanston, Ill., Northwestern Univ., 1966. 118p.

Thesis.

The steady flow of an electrically conducting fluid past a semi-infinite flat plate in the presence of a transversely applied magnetic field is considered. By linearizing the basic equations of the flow and applying Fourier transforms, the solution of the problem is reduced to solving a single Wiener–Hopf type of equation. This is done in an approximate manner and the resulting flow fields for various values of fluid conductivity are then derived and discussed. (Disser. Abstr.)

2912 UNSTEADY MAGNETOHYDRODYNAMIC FLOW PAST THIN BODIES WITH INWARDLY DIFFUSING MAGNETIC FIELD. Fan, Dah-nien. Ithaca, N. Y., Cornell Univ., 1967. 41p.

Thesis.

A rational small-perturbation theory is proposed for treating an initial- and boundary-value problem in magnetohydrodynamic flow past thin symmetrical bodies with the thickness parameter ϵ as the perturbation parameter. An irrotational flow over the body is established initially in the total absence of electromagnetic interactions. The fluid is assumed to be incompressible, inviscid, and electrically conducting. Moreover, it is bounded by two infinite parallel planes outside in which vacuum prevails. The external magnetic field is then imposed by turning on current sheets of constant intensity at the fluid–vacuum boundaries. The inwardly diffusing field penetrates the fluid, modifies the flow, and in turn is itself modified. Perturbation series valid, respectively, in the interior of the electrically insulating body and its exterior (the fluid and the vacuum) are written in powers of ϵ. Although the perturbation is a regular one, the matching of the interior and exterior expansions employed in the development of the theory bears a striking resemblance to the matching of the inner and outer expansions in the viscous boundary-layer theory. The zeroth- and first-order solutions are obtained analytically for an arbitrary body shape. The establishment of Lary's steady flow past a thin body at super- or sub-Alfvénic conditions, the existence of small-perturbation solutions at exactly Alfvénic flows, and the appear-

ance of an accumulation point of poles to characterize the transient behavior of a physical system are the interesting features which emerge in the course of the work. (Disser. Abstr.)

Geophysics

Refer also to abstracts 2866–2868, 2875, and 2877.

2913 ELECTRON PRECIPITATION IN CONJUGATE REGIONS OF THE AURORAL ZONES. Barcus, J. R. (Univ. of Denver). pp 229-59 of Recent Advances in Cosmic Ray Research. Gauger, J.; Masley, A. J. (eds.). North Hollywood, Calif., Western Periodicals Co., 1966.

From Symposium on Recent Advances in Cosmic Ray Research, Huntington Beach, Calif., Apr. 3–7, 1966. See CONF-660445.

In order to examine more directly the extent to which electron precipitation is actually similar and simultaneous at conjugate points, two coordinated series of high altitude balloon flights utilizing bremsstrahlung x-ray detectors have been carried out over the past four years. It is largely the results of these balloon programs which are discussed. An attempt is made to point out some potentially important measurements which might be sought in future investigations. (W.D.M.)

2914 COORDINATED EXPERIMENTS ON AURORAS. Evans, J. E. (Lockheed Palo Alto Research Lab., Palo Alto, Calif.). pp 261-85 of Recent Advances in Cosmic Ray Research. Gauger, J.; Masley, A. J. (eds.). North Hollywood, Calif., Western Periodicals Co., 1966.

From Symposium on Recent Advances in Cosmic Ray Research, Huntington Beach, Calif., Apr. 3–7, 1966. See CONF-660445.

The progress made by the Lockheed Palo Alto Research Labs and other cooperating laboratories in a coordinated experiment on aurorae which is directed primarily toward understanding the particle–atmosphere interaction phase of auroral phenomena is described. The program of this experiment includes particle measurements from an instrumented polar-orbiting satellite, luminosity profile and homogeneity measurements from instrumented aircraft and ground stations underneath the satellite, and electron content measurements. (W.D.M.)

2915 THEORY OF THE MOTION OF A VORTEX RING SUBJECTED TO GRAVITY FORCE. ASCENT OF AN ATOMIC CLOUD. Onufriev, A. T. Zh. Prikl. Mekh. Tekh. Fiz., No. 2, 3-15(Mar.-Apr. 1967). (In Russian).

The motion of the vortex ring of a nuclear or chemical explosion with gravity taken into account is analyzed using a series of equations that also take into account the effects of turbulent mixing and adiabatic expansion. Cases of vortex motion in which the internal density differs little or not at all from the ambient density are considered. Such studies, it is noted, are important in monitoring radioactive fallout distribution following a nuclear burst. The explosion sequence is traced from the initial propagation of the shock wave to the formation and gradual ascent of the fire ball causing the rising air to form the vortex ring, and finally, to the subsequent flattening of the atomic cloud into the characteristic mushroom shape. The cloud development process is initially controlled by an Archimedean force caused by the difference in density between the cloud and the ambient atmosphere, then by frictional forces causing turbulent mixing and the vortex motion, then, as the ascent velocity increases, the cloud-top flattening is caused by pressure differences, until finally the ascending cloud assumes the form of a torus or anchor ring in which the air rotates around a horizontal ring-axial line and around which a circulatory air current is generated. Owing to the circulation surrounding the vortex ring, a Zhukovskiy force perpendicular to the direction of the ring motion is set up, drawing the ring off to the side and decelerating the ascent. The problem of the ascent of the vortex ring is solved on the assumption that: (1) the pressure inside the ring equals that of the ambient atmosphere; (2) density, temperature, velocity, and vorticity inside the ring are similar throughout; (3) turbulent mixing of hot and cold air occurs at the ring surface; (4) the motion of the vortex ring is the same as that of a round cylinder; and (5) the temperature and pressure in the atmosphere agree with the international standard atmosphere. The results of computations are compared with experimental, primarily non-Soviet, data. (ATD)

2916 ANALOGUE SPECTRAL ANALYSIS OF GEOMAGNETIC MICROPULSATIONS IN THE RANGE 10 TO 200 SECONDS. Ku, C. C.; Jones, F. W.; Geldart, L. P. (McGill Univ., Montreal). Can. J. Phys., 45: 3743-51(Nov. 1967).

An analog method was used to compute the power spectra of three orthogonal micropulsation components recorded at Mont St. Hilaire, Quebec, Canada (geographic coordinates: N 45°32′, W 73°09′) on four selected days. The computed spectral peaks are plotted against Local Mean Time (E.S.T.) to show the diurnal variation of the micropulsations for the three components. In general, the geomagnetic oscillations in the range 10 to 200 sec consist of several different periods which correlate well among the three components. The dominant periods (as shown by the dominant spectral peak) of the north–south component and the vertical component are in general the same. The dominant period of the east–west component is in some cases different from that of the other two. On some days the dominant periods vary; on other days they stay essentially unchanged. (auth)

2917 ELECTRON TEMPERATURE IN AURORA. Hirao, Kunio (Tokyo Univ.). J. Geomagnet. Geoelec., 19: 247-51 (1967).

Electron temperature, incoming electron flux, and auroral brightness were observed with two Aerobee rockets at Fort Churchill by J. C. Ulwick and his coworkers. A remarkable layer-like structure is found in their data. It has been shown that the apparent layer structure is caused by the geomagnetically controlled incoming auroral electron. (auth)

2918 INVESTIGATION OF RADIO-WAVE PROPAGATION IN NONHOMOGENEOUS MAGNETOACTIVE ATMOSPHERE. Kazantsev, A. N.; Lukin, D. S.; Spiridonov, Yu. G. Kosm. Issled., 5: 593-600(July-Aug. 1967). (In Russian).

A geometric–optical method for the investigation of the propagation of radio waves, based on the solution of a system of normal differential equations of the first order, was proposed. The equations describe the light trajectory in the three-dimensional nonhomogeneous magnetoactive ionosphere. Solutions of the system of usual first-order differential equations were made, on the basis of which in the geometric–optical approximation, expressions were obtained for the time-neutralized quadrate of the spherical waves, dense waves, and wave bundles. The expressions obtained for the time-neutralized quadrate of the field intensity agree with the first term of the resolution of the asymptotic solution of the multiple scalar wave equation with a uniformly moving series. The theory developed can be used for investigation of the mechanism for the propagation of radio waves in nonhomogeneous magnetoactive ionosphere, the calculation of the field intensity of the radio waves, the calculation of the trajectory and delay time of static atmospherics, investigation of refraction, and Doppler shift of particles in the ionosphere and troposphere. (tr-auth)

2919 MEASUREMENT OF THE TOTAL ENERGY OF CORPUSCULAR FLUX AT 200 TO 500 km ELEVATION. Kazachevskaya, T. V. Kosm. Issled., 5: 637-9(July-Aug. 1967). (In Russian).

Measurements of the flux of ionizing radiation at heights of 200 to 500 km were made by a geophysical rocket in July of 1963. The basic results obtained concerned the electron flux. The measurements were tabulated and show that at heights from 250 to 515 km the signals do not vary with height. From measurements with filtered and unfiltered plastics, the energy of the solar x radiation was evaluated as $\ll 3$ erg/cm^2 sec and $\gg 0.08$ erg/cm^2 sec for $\lambda \ll 1038$ Å and $\lambda \ll 44$ Å, respectively. These values agree with previous measurements. (J.S.R.)

2920 CALCULATIONS OF RADIO-WAVE REFRACTION IN HORIZONTALLY NON-HOMOGENEOUS TROPOSPHERE AND IONOSPHERE. Kazantsev, A. N.; Lukin, D. S.; Fominykh, S. I.; Kruglov, V. P.; Pateev, V. E. Kosm. Issled., 5: 766-71(Sept.-Oct. 1967). (In Russian).

Numerically integrated first-order differential equations were used for computing the angles of refraction and errors caused by additional signal delay in spherically layered and horizontally nonhomogeneous models of the troposphere and ionosphere. (tr-auth)

2921 INFLUENCE OF IONS ON TRANSMISSION OF ULTRALOW FREQUENCY ELECTROMAGNETIC WAVES THROUGH THE IONOSPHERE. Aksenov, V. I.; Lishin, I. V. (Inst. of Radio Engineering and Electronics, Moscow). Radiotekh. Elektron., 12: 703-5(Apr. 1967). (In Russian).

In a previous paper [Aksenov, Radiotekh. Elektron., 11: 1030 (1966)], the problem of propagation of ultralow-frequency waves through a plane-layered magnetically active ionospheric plasma was solved for the case of longitudinal propagation (the angle between the magnetic wave vector and direction of the external magnetic field is zero, and the magnetic field is perpendicular to the layers). The problem was solved by integrating the wave equation with a complex refraction index, without taking into account the movement of molecules and ions; therefore, all the calculations were made for frequencies $f \geq 1.5$ kHz, satisfying the condition $\omega \gg \Omega_H$ (Ω_H = gyrofrequency of the ions), for which the effects of

the ions are negligible. An attempt is made here to solve the problem by taking into account the effect of ions at frequencies below 1.5 kHz. Integration of the wave equation was performed for height intervals of 50 to 200 km for the diurnal and 75 to 200 km for the nocturnal ionospheric models at frequencies from 50 Hz to 5 kHz. Since the ordinary wave for this frequency (as shown in the previous paper) does not penetrate the ionosphere, the calculations were made only for the extraordinary wave. The results show that consideration of positive and negative ions in the ionosphere has a small effect on the coefficients of transmission and refraction for the ionospheric model and frequency band considered. (ATD)

2922 DEPENDENCE OF THE RELATIVE INTENSITIES OF SOME OF THE AURORAL LINES UPON THE ENERGY SPECTRUM OF PRECIPITATING ELECTRONS. **Kamiyama, Hiroshi** (Tohoku Univ., Sendai). Sci. Rep. Tohoku Univ., Fifth Ser., 18: 83-90(Mar. 1967).

Estimates are made of the luminosities at λλ 3914, 5577, and 6300 resulting from the isotropic incidence of monoenergetic electrons precipitating into the atmosphere. As the incident energy of electrons increases, the height at which the excitation rate maximizes is lowered. In the lower region of the atmosphere, the excitation rate of O relative to that of N_2^+ decreases because of the smaller fraction of atomic oxygen, and further, the O I line emissions are extremely suppressed by the deactivation processes. Consequently, the O I line intensity maximizes at 1.6 keV of the incident electron energy for the red line and at about 8 keV for the green line, while a monotonous increase is found in the intensity of the N_2^+ bands as the incident energy of electrons increases. Assuming the exponential law, $\exp(-E_e/\beta)$ in which β is a parametric constant, for the differential energy spectrum of incident electrons, the luminosities of the above-mentioned auroral lines are shown as the function of β. As β increases, the ratio of the red line intensity to the green line intensity decreases rapidly at smaller values of β and slowly at greater β values, while the ratio of the intensity at λ 3914 to the green line intensity increases in a monotonous manner from about 0.6 at $\beta = 1$ keV to about 8 at $\beta = 20$ keV. Comparing the result with some of the observational data of auroras, a suggestion is given about the energy spectrum of electrons causing auroras. (auth)

2923 INFLUENCE OF SUNSPOTS ON DIFFERENT TYPES OF DIURNAL GEOMAGNETIC VARIATIONS. **Ochabova, Petronela** (Geophysical Inst., Bratislava). Stud. Geophys. Geod., 11: 465-9(1967).

When investigating the dependence of the characteristic of Sq variation of the geomagnetic field on solar activity represented by the relative sunspot number, it was pointed out that there are differences in the relations between the average and individual phenomena. Real Sq variations are much less dependent on the corresponding indices of solar activity, regarded as the measure of wave ionizing radiation, than the average diurnal variations. An attempt is made to show that a comparison of the average data can lead to problematical results. (auth)

2924 IONOSPHERIC IRREGULARITIES CAUSED BY ACOUSTIC WAVES. **Rai, D. B.; Kisabeth, J. L.** (Univ. of Alaska, College). Nature (London), 216: 568-9(Nov. 11, 1967).

Some observational evidence is presented concerning ionospheric irregularities formed because of the propagation of acoustic waves believed to have been associated with an earthquake experienced at College, Alaska. The motion of the neutral component in a partially ionized gas also affects the ionized components, and acoustic waves propagating in the ionosphere may therefore create perturbations in ionization which can be detected by radio methods. Attempts have been made to explain the origin of sporadic E in the equatorial regions as due to irregularities caused by acoustic waves, with application also to the auroral E region. Some results from a partial reflection experiment at 3 Mc are presented, providing observational evidence in support of the underlying theory. On the morning of June 21, 1967, rapid periodic echo fading was observed in the wake of an earthquake, and data concerning this fading are presented and discussed. The disturbance appears to have arrived at the reflecting region in a series of pulses. The observed regular sequence of increasing period had not been observed on any other occasion. The speed of propagation appeared to be about 350 m/sec., which is quite close to acoustic speed. Ionograms also indicated that the ionosphere was disturbed by the earthquake. It is suggested that the observed fading could be produced by acoustic waves propagating at below the critical angle, and that the vertical motion causing Doppler shift is the vertical component of the wave velocity. (UK)

2925 ALFVEN'S VELOCITY IN THE MAGNETOSPHERE ACCORDING TO NEW DATA ON THE CONCENTRATION OF COLD PLASMA. **Van'yan, L. L.; Al'perovich, L. S.** Kosm. Issled., 5: 472-5(1967). (In Russian).

The Alfvén velocity in the magnetosphere was calculated using data on electron concentration of cold plasma obtained by the United States Orbital Geophysical Observatory OGO-A. The magnetosphere was divided into two regions. The outer region was represented by Kamiyama and Takaki's collisionless model. The density isolines in this region were similar to the force lines of the geomagnetic field. The geomagnetic field was represented by the Mead and Beard model for Kp ≃ 1. The inner region of the magnetosphere with density distribution along the force line was taken to be in accordance with the diffusion law. The meridional distribution of the electron density at a height of 1000 km symmetric with respect to the equatorial plane was found to be in agreement with the data obtained by Explorer 22. Using the density distribution and the intensity of the geomagnetic field, the Alfvén velocity was calculated and represented graphically. Certain characteristic features of the graph are presented. A region of lower-than-normal velocities (V_A 600 to 800 km/sec) exists at a distance of 3 to 5 terrestrial radii (R). At low latitudes the presence of a peak at L ≃ 5Rz shows that waves with periods T ≃ 10 to 20 sec will be diffracted at this maximum. At high latitudes, a zone of very high velocities ($V_A \simeq$ 5000 to 10,000 km/sec) appears. The peaks of V_A appear above the polar zones independently of the presence or absence of a knee. On the night side of the magnetosphere, the Alfvén velocity decreases gradually to $V_A \simeq 100$ km/sec; however, in the neutral layer, it decreases sharply owing to a decrease in the intensity of the magnetic field. (ATD)

2926 DIRECT MEASUREMENTS OF DAY AND NIGHT PROFILES OF CHARGED-PARTICLE CONCENTRATION BELOW 80 km. **Bragin, Yu. A.** Kosm. Issled., 5: 478-9(1967). (In Russian).

In April 1966, over the midlatitudes of the USSR, a single instrument was used in repeated measurements of day and night profiles of the charged-particle concentration below 80 km. There was a 6-day interval between the daytime and nighttime measurements, with a quiet Sun and identical ballistic characteristics in both experiments. An analysis of the data indicates the following: (1) the results confirm a previously noted increase in the ion content of the stratosphere at an altitude of 10 to 40 km and a minimum ion concentration at 50 to 70 km; (2) the night profile of the ion concentration has its maximum at 10 to 40 km, and its minimum at 50 to 70 km; (3) local concentration minima are detected below 50 km in the background of a general increase in the charged-particle concentration in both the stratosphere and the upper troposphere; (4) below 70 and below 20 km, more light ions are present at night than in the daytime; (5) above 70 km there are more charged particles during the day than at night; and (6) above 20 km a sharp decrease in the ion concentration, both local and general, is observed during daytime in the upper portion of the stratospheric maximum. (ATD)

2927 SIMULTANEOUS SATELLITE AND BALLOON OBSERVATIONS OF THE SAME AURORAL-ZONE PRECIPITATION EVENT. **Milton, D. W.** (Univ. of California, Berkeley); **Oliven, M. N.** J. Geophys. Res., 72: 5357-61(Nov. 1, 1967).

On September 20, 1963, the Injun-3 satellite, at an altitude of 2350 km, passed within close proximity of a balloon x-ray detector at 35-km altitude. During a transit of the L shell of the balloon, a marked correlation in the increases of flux of the satellite-precipitating electron E ≥ 40-keV detector and the balloon x-ray E ≥ 30-keV detector is found. These results place a lower limit of 430 km east–west extent of the mutually observed pulsation event. (auth)

2928 POLAR SOLAR DAILY GEOMAGNETIC VARIATIONS ON EXCEPTIONALLY QUIET DAYS. **Kawasaki, K.; Akasofu, S.-I.** (Univ. of Alaska, College). J. Geophys. Res., 72: 5363-71(Nov. 1, 1967).

The analysis of magnetic records from the polar regions on two exceptionally quiet days (May 8, 1964, K_p = 0o0o0 + 0o 0o0 + 0 + 0 +, $\Sigma K_p = 1+$; December 10, 1963; K_p = 0o0o0 + 0o0o0o0o0o, $\Sigma K_p = 0+$) confirms the conclusion reached by Hasegawa and Nagata and Kokubun that the polar S_q variation consists of two parts, S_q^0 and S_q^p. However, the distribution of the S_q^p field obtained in the present analysis differs significantly from that obtained by the earlier workers in that there is a lack of significant change in the midnight sector. This result may be contrasted with the field caused by the polar electrojet, which is strongest in the midnight sector. (auth)

2929 ROCKET PHOTOMETRY OF THE FAR UV TWILIGHT AIRGLOW. **Moos, H. W.; Fastie, W. G.** (John Hopkins Univ., Baltimore). J. Geophys. Res., 72: 5165-71(Nov. 1, 1967).

Far-uv photometer measurements of the (dawn) twilight airglow are reported. Ly α showed a height profile similar to that of the dayglow with a peak value of 3.6 kr at a height of 152 km. At a height of 113 km there was no difference in the zenith and dawn horizon signals to within 10%. The O I 1304-Å signal had a maximum value of 110 R toward the horizon. Low-intensity emission in the wavelength region 1360 to 1600 Å was observed. (auth)

2930 MAGNETIC MORPHOLOGY OF SOLAR STREAMS AND ITS RELATION TO GEOMAGNETIC STORMS. Ballif, J. R.; Jones, D. E. (Brigham Young Univ., Provo, Utah). J. Geophys. Res., 72: 5173-84(Nov. 1, 1967).

Based on the results obtained from the Mariner-4 magnetometer experiment, a model of the magnetic properties of solar streams is presented. A model of geomagnetic variability described in terms of the K_p index that corresponds to the passage of the Earth through such a solar stream is also presented. The most significant magnetic characteristic of simple streams is that they can be described in terms of a core of high, uniform field surrounded by an asymmetric region of fluctuating fields. Geomagnetic variability occurs when the Earth is in the disordered field region. Therefore, when the earth passes through the uniform field in the core of a stream there is a temporary lull in the geomagnetic storminess observed at the Earth. Many of the observed solar–geomagnetic correlations are reviewed and are found to relate well to the proposed model. (auth)

2931 RESPONSE OF THE GEOMAGNETIC ACTIVITY INDEX K_p TO THE INTERPLANETARY MAGNETIC FIELD. Schatten, Kenneth H.; Wilcox, John M. (Univ. of Calif., Berkeley). J. Geophys. Res., 72: 5185-91(Nov. 1, 1967).

Interplanetary magnetic field data obtained by IMP 3 during eight solar rotations in the latter half of 1965 have been compared with the 3-hour K_p index. The results are consistent with those obtained by IMP 1 during three solar rotations in the winter of 1963–1964, indicating a stability in the response of geomagnetic activity during these years near solar activity minimum. On the average an interplanetary magnetic field with a southward component is generally more geomagnetically effective than a field with a northward component. This is consistent with the reconnection of interplanetary and geomagnetic field lines as suggested by Dungey. As a function of interplanetary field magnitude B, the average value of the index a_p is more linear than K_p, as might be expected. The relation can be described by $\langle a_p \rangle = (1.5 \pm 0.1)\ B + 0.7 \pm 0.5$. In the time interval covered by these observations the average value of K_p is consistently higher in sectors with the interplanetary field directed away from Sun than in sectors with the field directed toward the Sun. (auth)

2932 BULK MOTION OF THE MAGNETOSPHERE. Brice, Neil M. (Cornell Univ., Ithaca, N. Y.). J. Geophys. Res., 72: 5193-5211(Nov. 1, 1967).

Fast magnetic field-line merging at the magnetospheric bow and in the tail are examined to determine their implications in regard to the concept of bulk motion of the magnetosphere (convection) and the associated electric field. Upper atmosphere geophysical measurements are surveyed to determine to what extent the available data support this concept. The dawn–dusk asymmetry in energetic particle fluxes, the movement of auroral ionization, ionospheric currents, and the location of the whistler knee (or "plasmapause") are all consistent with this concept, the latter three all giving estimates of the electrostatic potential difference across the magnetosphere in the dawn–dusk meridian of a few tens of kilovolts. A "present best estimate" of the flow pattern in the magnetosphere is derived, based primarily on the diurnal variation in the location of the whistler knee. The convective flow in from the tail appears to be stronger before midnight than after, which is consistent with the location of the maximum nighttime precipitation of energetic electrons. The derived flow is also qualitatively in agreement with that deduced from field-line merging. However, the Axford–Hines types of viscous drag will also give rise to convective flow, and the currently available data do not allow a definitive determination of whether field-line merging or viscous interaction is the principal driving force. (auth)

2933 LIMITING OF MAGNETOSPHERIC CONVECTION BY DISSIPATION IN THE IONOSPHERE. Walbridge, E. (Univ. of Chicago). J. Geophys. Res., 72: 5213-30(Nov. 1, 1967).

The constant of proportionality between the magnetospheric convection velocity and the magnetic stressing required to produce that velocity is obtained. This constant, the drag coefficient, is independent of the mechanism that drives the convection. From the drag coefficient the rate of dissipation due to joule and viscous heating is obtained as a function of the convection velocity. The driving mechanism must supply at least as much energy as is thus dissipated. It is found that the maximum rate at which the solar wind can do work on the magnetospheric plasma is much greater than is required for supplying the energy dissipated, even with convection velocities as high as about 1 km/sec (in the ionosphere). Given velocities as high as 1 km/sec, a number of interesting consequences follow, such as particle energization and the Ds current system. The role of viscosity in the dynamics of the ionosphere is assessed. It is found that viscous dissipation is usually not significant. The effect of neutral gas motions on the joule dissipation is considered. (auth)

2934 PLASMAPAUSE OBSERVATIONS WITH THE M.I.T. EXPERIMENT ON IMP 2. Binsack Joseph H. (Massachusetts Inst. of Tech., Cambridge). J. Geophys. Res., 72: 5231-7 (Nov. 1, 1967).

The M.I.T. plasma experiment flown on the IMP-2 satellite has detected the boundary of the region of dense thermal ions in the inner magnetosphere. The location of this boundary corresponds to the knee region investigated by whistler techniques. In the dawn hemisphere the boundary assumes a nearly circular shape during times of low magnetic activity (3-hr $K_p \leq 1$). An empirical relationship between the average L shell of the boundary and the 3-hr K_p index has been found to be $L = 6 - 0.6\ K_p$. (auth)

2935 LOWER IONOSPHERE ELECTRON CONCENTRATION AND COLLISION FREQUENCY FROM ROCKET MEASUREMENTS OF FARADAY ROTATION, DIFFERENTIAL ABSORPTION, AND PROBE CURRENT. Mechtly, E. A. (Univ. of Illinois, Urbana); Bowhill, S. A.; Smith, L. G.; Knoebel, H. W. J. Geophys. Res., 72: 5239-45(Nov. 1, 1967).

In a new type of radio propagation experiment, radio waves of both magnetoionic modes are radiated from a pair of ground-based transmitters to a Nike Apache rocket. A power ratio of 10 db at the rocket is maintained by a servoloop that includes the transmitters, the rocket-borne receiver, and the telemetry system. The frequencies of the two modes are controlled by crystals that differ in frequency by 500 Hz. The central frequency is 3385 kHz. This technique facilitiates measurement of ionospheric Faraday rotation and differential absorption by well-calibrated instrumentation located on the ground. A method of analyzing Faraday and absorption data, based on the generalized magnetoionic theory, is developed and applied to rocket data to obtain electron concentration and collision frequency, and to calibrate a Langmuir-type electron current probe that measures the fine structure of the electron concentration profile. Results of a typical flight are shown in which electron concentrations are determined in the altitude range 55 to 105 km and collision frequencies in the range 85 to 105 km. (auth)

2936 THE SOLAR-FLARE RADIATIONS RESPONSIBLE FOR SUDDEN FREQUENCY DEVIATIONS. Donnelly, R. F. (Inst. for Telecommunication Sciences and Aeronomy, Boulder, Colo.). J. Geophys. Res., 72: 5247-56(Nov. 1, 1967).

The solar-flare radiations responsible for a type of sudden ionospheric disturbance called "sudden frequency deviation" (SFD) are investigated. It is shown that x-ray bursts at wavelengths less than 0.6 Å and Lyman-α enhancements do not contribute significantly to SFD's. X-ray bursts at 0.6 to 10 Å are of minor importance to SFD's. X-ray bursts at 10 to 100 Å do contribute significantly to SFD's, but flashes of radiation at wavelengths greater than 100 Å are required to explain most SFD's. (auth)

2937 GROSS LOCAL-TIME PARTICLE ASYMMETRIES AT THE SYNCHRONOUS ORBIT ALTITUDE. Freeman, J. W. Jr.; Maguire, J. J. (Rice Univ., Houston, Tex.). J. Geophys. Res., 72: 5257-64(Nov. 1, 1967).

A low-energy charged-particle detector has been flown aboard the geostationary ATS-1 satellite. A preliminary study of the data has revealed large local-time variations in the particle fluxes observed during geomagnetically disturbed times. The salient features of the observed variations are: (1) During periods of moderate magnetic activity a high particle flux is seen near local midnight. This flux shows a strong pre/postmidnight asymmetry with the particle intensities being higher in the postmidnight quadrant. (2) During periods of high magnetic activity the enhanced particle flux distribution broadens out in local time to cover a larger fraction of the nightside portion of the synchronous orbit. The pre/postmidnight asymmetry is generally still present but less striking. (3) During periods of enhanced magnetic activity the local-time distribution of the particle fluxes shows a remarkable similarity to the local-time distribution of high-latitude magnetic substorm activity. It is suggested that the observed particle distribution is indicative of an influx of energetic plasma from the magnetospheric tail. Implications relating to magnetic storm models are discussed. (auth)

2938 SOLAR WIND THERMAL ANISOTROPIES: VELA 3 AND IMP 3. Hundhausen, A. J. (Los Alamos Scientific Lab., N. Mex.); Bame, S. J.; Ness, N. F. J. Geophys. Res., 72: 5265-74(Nov. 1, 1967).

Solar-wind proton velocity distribution functions derived from Vela-3 satellite observations made during July and August 1965 are usually anisotropic in a frame of reference moving with the bulk velocity of the medium. The orientations of these anisotropic distributions are here compared with the directions of the interplanetary magnetic field measured on the IMP-3 satellite. On August 3, 4, and 5, 1965, under relatively quiet conditions, the direction of maximum proton temperature was aligned with that of

the magnetic field lines. The detailed temporal behavior of the anisotropy and field directions followed the same pattern during periods of slow changes and during the passage of a "magnetic filament" past both satellites. The alignment of the anisotropic distributions and the field lines is shown to hold for the 33-day period for which these data have been compared. Some consequences of the possible plasma instabilities implied by this situation are suggested. (auth)

2939 THE DOUBLE SHOCK-WAVE STRUCTURE IN THE SOLAR WIND. Schubert, G.; Cummings, W. D. (Univ. of California, Los Angeles). J. Geophys. Res., 72: 5275-86(Nov. 1, 1967).

A one-dimensional model of the double shock structure in an inviscid, perfectly conducting fluid is presented. A magnetic field parallel to the discontinuity surfaces is included in the analysis. The range of ambient and driver gas parameters for which a double shock is possible is determined, and in particular, the effect of the magnetic field on these critical curves is examined. Theoretical shock profiles for typical solar wind conditions are discussed. Mariner-2 data for the high velocity stream of October 7–8, 1962, are compared with the results of the one-dimensional model. It is shown that the peak in the density should precede the peak in the magnetic field strength. This feature is in agreement with Mariner-2 data. The model yields values of temperature and pressure in the shocked gases that are higher than observed. (auth)

2940 NONLINEAR INFLATION OF A MAGNETIC DIPOLE. Parker, E. N.; Stewart, H. A. (Univ. of Chicago). J. Geophys. Res., 72: 5287-93(Nov. 1, 1967).

It is shown that some aspects of the nonlinear inflation of a magnetic dipole by a plasma may be simply understood by considering the case where the gas pressure has a similarity form. All stages of the inflation are treated, from the undisturbed dipole to the limiting case of lines of force stretched to a radial configuration. The total energy of particles and field is found to rise monotonically with increasing gas pressure to a finite maximum. The field will contain plasma only up to a certain maximum pressure. Complete numerical results embodying these nonlinear effects are tabulated for several field configurations. A discussion is given of the relevance of this work to phenomena occurring during the geomagnetic storm. (auth)

2941 ON THE BOUNDARY LAYER BETWEEN A WARM, STREAMING PLASMA AND A CONFINED MAGNETIC FIELD. Lerche, I. (Univ. of Chicago). J. Geophys. Res., 72: 5295-5310(Nov. 1, 1967).

Conditions are derived under which a magnetic field can be confined by a warm plasma composed of electrons and protons when the plasma has a bulk velocity parallel to the confined field. It is shown that unless the electrons have about 10^3 as much thermal energy as the ions, it is extremely unlikely that an equilibrium state can exist. It is further shown that, in general, there will be a component of field normal to the confined field and also normal to its gradient and that if the plasma is not streaming, then a necessary, but not sufficient, condition for equilibrium is that this "extra" field component be identically zero. It is suggested that this calculation may have some bearing on the state of the geomagnetic field–solar wind boundary, particularly on the tail side of the Earth. (auth)

2942 CORRELATION OF RADAR ECHOES FROM THE AURORA WITH SATELLITE-MEASURED AURORAL PARTICLE PRECIPITATION. Leadabrand, Ray L.; Hodges, James C. (Stanford Research Inst., Menlo Park, Calif.). J. Geophys. Res., 72: 5311-17(Nov. 1, 1967).

A 139- and 398-MHz auroral radar located at Homer, Alaska, was used to study the correlation between radar auroral echoes and the precipitating charged particles, as measured by a polar orbit satellite, producing the aurora. On the several satellite passes that showed on significant precipitating particles in the region that could be observed by the radar, no radar auroral echoes were obtained. On the one pass when both precipitating electrons and protons were detected by the satellite, the radar obtained auroral echoes that were most closely correlated in space with the >2-keV electrons, and no echoes were associated with the peak position of the >20-keV proton precipitation. The energy of the electrons measured is sufficient to produce ionization in the height region from which the echoes are obtained. The very close spatial relationship between the auroral echoes and the precipitating electrons indicates that for this particular case the primary generating mechanisms for the echo-producing auroral ionization are precipitating electrons. (auth)

2943 TOTAL ELECTRON CONTENT AND ITS VARIATIONS IN THE AURORAL-ZONE IONOSPHERE DURING WINTER. Rai, D. B.; Hook, J. L. (Univ. of Alaska, College). J. Geophys. Res., 72: 5319-24(Nov. 1, 1967).

Ionospheric electron content in the auroral and subauroral zone during winter has been determined from the differential Doppler measurements of radio signals from the satellite 1963-38C. The latitudinal variations of the electron content show a regular pattern on quiet days and change markedly during magnetic activity. The observations indicate a systematic pattern of the effect of magnetic disturbance. In general the electron content near 65°N (geographic on College meridian) increases during disturbed periods. The latitudinal distribution also shows a peak near this latitude. The diurnal variation of the electron content during quiet periods shows a secondary maximum at night in the latitude range 65 to 75°N. This secondary maximum is believed to be caused by precipitation of low-energy electrons. (auth)

2944 INCOHERENT SCATTERING AT PERPENDICULAR INTERSECTION WITH THE EARTH'S MAGNETIC FIELD. Baron, M.; Petriceks, J. (Stanford Research Inst., Menlo Park, Calif.). J. Geophys. Res., 72: 5325-9(Nov. 1, 1967).

The theory of incoherent scattering of radio waves by a plasma predicts that for unequal ion and electron temperatures, the scattering cross section is dependent on the angle between the radar ray and the Earth's magnetic field. The magnitude of this dependence has been calculated and verified experimentally for an incident radar frequency of 1290 MHz. (auth)

2945 VARIATIONS IN TOTAL ELECTRON CONTENT AND OTHER IONOSPHERIC PARAMETERS ASSOCIATED WITH MAGNETIC STORMS. Hibberd, F. H. (Univ. of New England, Armidale, New South Wales); Ross, W. J. J. Geophys. Res., 72: 5331-7(Nov. 1, 1967).

The storm-time variations of the ionosphere in middle latitudes during ionospheric storms are described. Usually the total electron content is increased during the first 24 hours of the storm. The total content then falls to below its quiet-day value and recovers after one or two days. The peak electron concentration in the F region is similarly increased at the beginning of the storm and is later depressed. The fall in peak electron concentration commences some hours earlier than the fall in total electron content. The equivalent slab thickness is increased above the quiet-day value throughout the storm, corresponding to an increase in the electron–ion temperature. In weak magnetic storms the ionospheric disturbance may not last longer than one day, and only the initial elevation of total electron content occurs. (auth)

2946 EFFECT OF REFRACTION CORRECTION ON THE LATITUDE VARIATION OF TOTAL ELECTRON CONTENT. Basu, Sunanda (Jadavpur Univ., Calcutta). J. Geophys. Res., 72: 5339-45(Nov. 1, 1967).

Faraday rotation data from the beacon satellites BEB(S-66) and BEC obtained at Calcutta (12°N geomagnetic) were used to compute the total electron content of the ionosphere as a function of latitude. Corrections for second-order effects have been applied using Ross' [1965] equations for manual data reduction. It is found that an exact solution of the quadratic equation in Ω, the rotation angle, obtained by the inclusion of second-order effects is necessary, and the iterated solution has to be used with caution when the prevailing electron content is high. The second-order electron content curve shows a marked discontinuity through the transverse region because of the extreme sensitivity of the refraction correction equations to the sign and magnitude of the geometrical parameter G. The extent of the validity of the quasi-longitudinal approximation of the Appleton–Hartree equation in the vicinity of the transverse region has been investigated, and the magnitude of the nonzero rotation at the transverse point has been computed. (auth)

2947 AN APPROXIMATE FLOW EQUATION FOR GEOMAGNETIC FLUX TUBES AND ITS APPLICATION TO POLAR SUBSTORMS. Atkinson, G. (California Inst. of Tech., Pasadena). J. Geophys. Res., 72: 5373-82(Nov. 1, 1967).

A recent model of polar substorms suggests they are the result of an impulsive recombination of magnetic field lines across the neutral sheet in the tail of the magnetosphere. The flow of flux tubes within the magnetosphere is shown to be dominated by the discharging action of the ionosphere on flux tubes. This fact enables an approximate flow equation for flow within the magnetosphere to be developed by integrating along flux tubes. This equation is applied to the above model of polar substorms and is shown to give reasonable agreement with the following experimental observations: (1) the velocity and flow pattern of auroral patches; (2) the height and shape of the auroral breakup bulge; and (3) the bay current system, including the westward electrojet under the assumption that the westward electrojet is current-induced by the southward component of flow of flux tube feet in the high conductivity strips under auroral arcs. These strips are expected to exhibit a Cowling conductivity. The westward traveling surge is probably caused by an increasing width of the recombination slot in the tail of the magnetosphere. The current flow down field lines

and through the ionosphere results in a density (and hence pressure) decrease in the neutral sheet at the west edge of the recombination slot, and thus causes a corresponding westward propagation of the west edge of the recombination slot. Application of the flow equations to the viscous boundary layer problem indicates an expotential falloff in velocity from the magnetosphere boundary with a 1/e distance of 5×10^4 m. (auth)

2948 RESONANCES OF A CYLINDRICAL EARTH-IONOSPHERE CAVITY MODEL WITH A DIPOLAR MAGNETIC FIELD. Large, David B.; Wait, James R. (Inst. for Telecommunication Sciences and Aeronomy, Boulder, Colo.). J. Geophys. Res., 72: 5395-5400(Nov. 1, 1967).

A cylindrical model of the earth–ionosphere cavity at elf with an angularly dependent surface-impedance boundary condition is analyzed. The variation of the ionospheric surface impedance is chosen to simulate the presence of a dipolar, radial, geomagnetic field. By neglecting TE–TM mode coupling, the coupling between TM modes is analyzed. Cavity resonant frequencies and quality factors as functions of ionospheric electron concentration and collision frequency are compared between constant and dipolar field configurations. Parameters that yield resonances close to experimental values are found for both configurations, and it is shown that the constant field model with an induction equal to $2/\pi$ times the polar induction produces resonances very close to those of the corresponding dipolar model. (auth)

2949 STATISTICAL APPROACH TO THE DETERMINATION OF THREE-DIMENSIONAL IONOSPHERIC DRIFTS. Fedor, L. S. (Inst. for Telecommunication Sciences and Aeronomy, Boulder, Colo.). J. Geophys. Res., 72: 5401-15(Nov. 1, 1967).

In a standard method inferring ionospheric motions from radio soundings the random echo amplitude variations observed at spaced receivers are compared by use of their auto- and cross-correlations. Graphical procedures devised by Briggs, Phillips, and Shinn (hereafter referred to as BPS) and adapted to digital computers by Keneshea, Gardner, and Pfister permit the steady drift, random motion, and geometric properties of the echo-pattern irregularities to be extracted. The method is very powerful, but it is difficult to assess the degree to which the assumptions underlying it are fulfilled in individual cases. Furthermore, although the problem is inherently stochastic, the BPS process does not provide a "best fit" of these assumptions to the available data. Finally, the BPS concepts are geometrically incomplete, since treatment of only the horizontal cross section of the ionospheric irregularities is implied. A description is given of a systematic numerical process based upon the concept of least squares that provides a best fit to the correlation functions obtainable from any number of spaced receivers deployed in any (nonsingular) manner over the ground. The analysis is developed in three spatial dimensions, anticipating new measurement methods in which vertical motions and ionospheric structure are observed by correlation of closely spaced frequencies or by other means. It is shown that the horizontal velocity components are not given correctly by the two-dimensional methods if vertical movements of anisometric irregularities occur. An example (two-dimensional) of the analysis by the new method is given and is compared with the analysis of Kenesha et al. in a case where the BPS criteria are closely met. The two methods agree well, but the new method appears to be capable of giving reasonable results in a wider variety of cases. (auth)

2950 OGO-A MAGNETIC FIELD OBSERVATIONS. Heppner, J. P.; Sugiura, M.; Skillman, T. L.; Ledley, B. G.; Campbell, M. (Goddard Space Flight Center, Greenbelt, Md.). J. Geophys. Res., 72: 5417-71(Nov. 1, 1967).

New findings that have come from the initial study of the OGO-A fluxgate magnetometer measurements between 4 and 24.5 R_E (earth radii) are summarized. These include the following: (1) A model magnetic field profile of the cross-sectional structure of the bow shock is derived in terms of the sharpness of the interface, the rise time, and the total time interval occupied by a field pile-up at the shock. Using a simple model to derive the velocity of shock movements, these times are converted to three thickness dimensions roughly of the order <20, 70, and 250 km, which emphasizes the need for strict definition of the meaning of "thickness" in collisionless shock theories. (2) Superimposed on the average shock structure, (1) above, two classes of field oscillations are frequently observed: coherent circularly polarized waves with frequencies typically between 0.5 and 1.5 cps in the satellite reference frame, and higher frequency fluctuations, >7 cps, which are unresolved by the measurements and whose identity is not known. The coherent oscillation is identified as being in the whistler mode, exists in the form of wave packets, and usually shows a sharp upper frequency cutoff in power spectrum analysis. (3) A series of bow shock crossings during the main phase of the April 18, 1965, magnetic storm occur at an abnormally large distance from the Earth principally as a consequence of the strong, 20 to 27 γ, interplanetary field that lowers the Alfvén Mach number to 1.5. The transition region magnetic field adjacent to the shock interface is exceptionally stable in contrast to a number of theoretical predictions and the typical shocks observed at high Mach numbers. (4) The magnetopause in the sunward hemisphere is most typically observed as a smooth transition over a dimension comparable to the ion cyclotron radius. (5) The correlation of negative bay onsets in the auroral belt with OGO-A observations on the night side of the Earth supports more general morphological arguments that the onset originates within the closed magnetosphere or auroral ionosphere and is not dependent on being triggered by a sudden change in the solar wind plasma or field. The view is advanced that the onset results from short-circuiting effects in the ionosphere. (6) At middle latitudes between 5 and 10 R_E near the midnight time sector the total field intensity is found to be considerably stronger than predicted by existing field models. This is believed to be caused by high plasma pressures near the equator at similar distances in the same time sector. (7) Near the magnetopause within the local time sector 4h30m to 6h30m and geomagnetic latitudes ±15° the magnetospheric field intensity is generally found to be $\leq B_t$, the field intensity in the adjacent transition region. This condition and the behavior of the field gradient within the magnetosphere leads to the conclusion that a $\beta \geq 1$ condition must persist over this sector of the outer magnetosphere beyond 11 R_E. The consequences of the magnetopause being a boundary between two high β regions are noted in terms of boundary instability, plasma entry, and the possible existence of secondary shocks in the transition region. A similar, but not identical, condition may exist in the evening twilight local time sector. (auth)

2951 MIDDAY RECOVERIES OF POLAR CAP ABSORPTION. Leinbach, Harold (Inst. for Telecommunication Sciences and Aeronomy, Boulder, Colo.). J. Geophys. Res., 72: 5473-83 (Nov. 1, 1967).

Riometer observations of midday recoveries of polar cap absorption (PCA) show that: (1) the recoveries peak in the local time range of 0800 to 1500, mostly between 1000 and 1200 LT; (2) the recoveries are most pronounced at the edge of the polar cap and not evident deep inside the polar cap; and (3) the midday recovery region remains at the edge of the polar cap as the polar cap expands during a magnetic storm. Some satellite data indicate that midday recoveries are the result of the development of an anisotropic pitch-angle distribution of the solar protons, rather than a simple increase of cutoff rigidity. The anisotropy is of the nature of a depleted loss cone; in addition, the 90° pitch-angle component is apparently reduced below its isotropic, non-midday recovery value. Model calculations of absorption using a $\sin^3 \theta$ pitch-angle distribution suggest that anisotropy, without appreciable increase of vertical cutoff energy, can cause midday recoveries of the observed magnitudes. Two outstanding features of midday recoveries yet to be explained are their presence during only about 20% of PCA events, and the fact that midday recoveries are usually pronounced on only one day of an event. (auth)

2952 RIOMETER QUIET DAY CURVES. Heisler, R.; Hower, G. L. (Washington State Univ., Pullman). J. Geophys. Res., 72: 5485-90(Nov. 1, 1967).

A direct method of obtaining a riometer quiet day curve of the correct shape is presented. The method is simple, and the only input information required is the early morning riometer readings. The corrected curve is shown to be necessary in studies of average ionospheric absorption levels and their diurnal, seasonal, and solar cycle variations. (auth)

2953 SHOCK WAVE TRAILING THE MOON. Michel, F. C. (Rice Univ., Houston, Tex.). J. Geophys. Res., 72: 5508-9(Nov. 1, 1967).

The standing shock wave behind the moon is examined. A schematic illustration of the structure behind the moon showing the rarefaction and shock waves is included. The schematic shows the propagation of a rarefaction wave into the unperturbed medium at the compressional wave velocity, together with the inward collapse of the medium into the vacuum directly behind the moon and the shock that must result when the collapsing fluid collides. Density profiles through the preshock and postshock regions are also shown. (J.H.M.)

2954 INTRINSIC MAGNETIC FIELD OF THE MOON. Sonett, C. P.; Colburn, D. S.; Currie, R. G. (Ames Research Center, Moffett Field, Calif.). J. Geophys. Res., 72: 5503-7 (Nov. 1, 1967).

Preliminary observations are reported of the magnetic field in the near neighborhood of the moon taken during the first and second lunar orbits of Explorer 35. (J.H.M.)

2955 FLUX DENSITY MEASUREMENTS OF RADIO BURSTS OF PROTON-PRODUCING FLARES AND NONPROTON FLARES. Castelli, John P.; Aarons, Jules (Air Force Cambridge Research

Labs., Bedford, Mass.). J. Geophys. Res., 72: 5491-8(Nov. 1, 1967).

Radio spectra of the maximum flux density of three of the proton events of 1966 have been analyzed in detail. Bursts from these proton-producing flares had distinct characteristics in the microwave portion of the spectrum and a typical shape in their flux density spectrograms. The spectral shape consists of the following: (1) high flux densities at meter wavelengths; (2) high flux densities at centimeter wavelengths; and (3) a minimum of flux density in the decimeter region. At all wavelengths, but especially at the meter wavelengths, high flux density persists over a relatively long time (type-IV burst). From the form shown on the flux density radio spectrogram, these characteristics are termed the "U"-shaped spectrum. The majority of earlier radio proton (PCA) events very clearly had this shape. Even the smaller PCA's, often discounted on lists of principal events, appear to have radio spectra similar in shape to the larger events. The recent nonproton flare of optical importance 4B (February 13, 1967) did not display this spectrum. Its radio spectrum and low intensity, moreover has not been found among PCA events. It appears, therefore, that for proton events with PCA effects traceable to flares on the visible disk of the sun, the U-shaped radio spectrum with high flux densities at meter and centimeter wavelengths is the "preferred spectrum." (auth)

2956 EXCITATION OF THE MAGNETOSPHERE BY THE SOLAR WIND. Coleman, Paul J. Jr. (Univ. of California, Los Angeles). J. Geophys. Res., 72: 5518-22(Nov. 1, 1967).

Evidence is presented to show that variations in the direction of V, the solar-wind plasma velocity, produce a significant part of the activity that is measured by K_p. The activity produced by these variations in V/V may well be dominant during periods of low to moderate K_p. However, other solar-wind quantities may also be effective in producing geomagnetic activity. (auth)

2957 SHOCK-ALIGNED MAGNETIC OSCILLATIONS IN THE MAGNETOSHEATH: MARINER 4. Siscoe, G. L. (California Inst. of Tech., Pasadena); Davis, L. Jr.; Coleman, P. J. Jr.; Smith, E. J.; Jones, D. E. J. Geophys. Res., 72: 5524-30(Nov. 1, 1967).

Magnetic field characteristics in the Earth's magnetosheath were observed by Mariner 4. Results are presented from the region where multiple shock transitions were observed. The data strongly suggest the existence of primarily torsional oscillations near the shock with periods between 10 and 40 sec in the spacecraft frame and planes of oscillation aligned roughly parallel to the expected shock front. Mariner 4 traversed the magnetosheath between 1 and 2 earth radii south of the ecliptic plane, essentially in the 0400 local time meridian plane. (J.H.M.)

2958 ENERGY-DEPENDENT MODULATION IN AURORAL X-RAY PULSATIONS. Brown, R. R.; Weir, R. A. (Univ. of California, Berkeley). J. Geophys. Res., 72: 5531-6(Nov. 1, 1967).

An analysis is made of relative changes in the x-ray spectra of pulsations that reveals regular changes, hardening and softening, as the peaks develop and decay. Considering optical observations, the analysis gives evidence for a close association between pulsations of energetic electron precipitation and visual aurora. The observations were obtained during a high-altitude balloon flight using an uncollimated NaI(Tl) scintillation counter with a multichannel pulse-height analyzer. (J.H.M.)

2959 VHF RADAR RETURNS FROM THE D REGION OF THE EQUATORIAL IONOSPHERE. Flock, Warren L.; Balsley, Ben B. (Jicamarca Radar Observatory, Lima). J. Geophys. Res., 72: 5537-41(Nov. 1, 1967).

Radar echoes from the ionospheric D region were observed at a location close to the magnetic equator. The results indicate that the predominant feature of the region is the presence of an echoing stratum at a height of about 75 km. Echo returns were present most of the time during daylight hours. For brief periods the echoing region split into at least two separate strata. (J.H.M.)

2960 ELECTRON CONTENT INHOMOGENEITIES IN THE LOWER IONOSPHERE. Goodman, John M. (Naval Research Lab., Washington, D. C.). J. Geophys. Res., 72: 5542-6(Nov. 1, 1967).

A Faraday rotation experiment was conducted at radio frequencies of 133 and 401 MHz in conjunction with six Gemini-9 spacecraft transits over Kauai, Hawaii, and Antigua, British West Indies, on June 4, 1966. The rotational ambiguity at 133 MHz was resolved upon inspection of the polarization angle corresponding to the radio frequency of 401 MHz. The polarization resolution was such that irregularities in electron content in excess of 2×10^{14} electrons/meter^2 could be detected. Over 130 inhomogeneities were analyzed and ranged between 6 and 530 km in horizontal scale. The irregularity excursion δC was roughly an increasing function of the irregularity scale δL with the percentage excursion increasing between 1 and 5% per 100 km. (auth)

2961 LUNAR TIDAL VARIATIONS IN THE EQUIVALENT SLAB THICKNESS OF THE IONOSPHERE OVER HAWAII. Rao, N. Narayana; Stubenrauch, C. F. (Univ. of Illinois, Urbana). J. Geophys. Res., 72: 5547-51(Nov. 1, 1967).

Results are presented of simultaneous lunar tidal analyses of ionospheric parameters deduced from bottomside soundings and Faraday rotation observation of the Syncom-3 signals during January–March 1965. The parameters investigated for lunar tidal variations are the total electron content, the F2 layer peak electron concentration, and the equivalent slab thickness of the ionosphere. It is concluded that results establish the existence of a nighttime lunar tide of significant proportion to that during the day in the F2 layer. (J.H.M.)

2962 ABSORPTION OF SOLAR X RAYS AND DENSITY CHANGES BETWEEN 140 AND 160 KILOMETERS. Thomas, L.; Norton, R. B. (Inst. of Telecommunication Sciences and Aeronomy, Boulder, Colo.). J. Geophys. Res., 72: 5552-4(Nov. 1, 1967).

Variations in density deduced from an analysis of 44- to 60-Å x-ray data obtained at six tracking stations from the NRL solar radiation satellite 1964-01-D during February and March 1964 are discussed. Absorption data were obtained when the Sun, as seen from the satellite, was occulted by the terrestrial atmosphere. This occurs when the satellite passes through the twilight zones. It is evident that satellite observations of the atmospheric absorption of solar x rays in twilight periods can, in principle, provide a convenient method for studying changes in atmospheric density between 120 and 200 km. (J.H.M.)

2963 LATITUDE VARIATION OF TOTAL ELECTRON CONTENT IN THE EQUATORIAL REGION. Basu, S.; Das Gupta, A. (Univ. of Calcutta). J. Geophys. Res., 72: 5555-8(Nov. 1, 1967).

Total electron content measurements, using the Faraday rotation method, carried out at the Haringhata Field Station of the University of Calcutta are presented to show the latitude dependence of total electron content as well as the diurnal variation of this latitude dependence. The measurements were carried out by receiving signals from satellites BEB and BEC at 40.010 Mc and cover a dip range of 20 to 34° dip north. (J.H.M.)

2964 DEDUCTION OF ELECTRON TEMPERATURE FROM F-REGION COMPONENT OF ABSORPTION OF COSMIC RADIO NOISE. Abdu, M. A.; Degaonkar, S. S. (Physical Research Lab., Ahmedabad, India). J. Geophys. Res., 72: 5559-62(Nov. 1, 1967).

Results are described of deduction of electron temperatures of cosmic radio noise recorded at Ahmedabad at 25 MHz during 1957–1958 and at 21.3 MHz during 1964–1965. A comparison is made of the diurnal variation of electron temperature deduced from measurements at Ahmedabad and that obtained from Explorer 8 and 17. It is shown that the diurnal maximum of electron temperature in the morning agrees well with Explorer-8 results. (J.H.M.)

2965 RADIATION FROM SOURCES IN LAYERED MEDIA INCLUDING MAGNETOPLASMA. Schell, Robert Ray. Tuscon, Univ. of Arizona, 1967. 147p.

Thesis.

Propagation of very low frequency (vlf) radio waves along the magnetic equator of the earth is considered. A flat-earth geometry is assumed wherein the earth is represented by a plane surface impedance and the ionosphere by a two-layer plasma. The lower region is a vertically stratified plasma with a dc magnetic field parallel to the earth, while the upper region is a homogeneous plasma. The source of electromagnetic waves is a magnetic line current which is parallel to the dc field and located in either the waveguide region between the earth and ionosphere or in the ionosphere. Under these conditions, the propagation in the inhomogeneous, anisotropic plasma is governed by a single, second-order differential equation which involves the components of the inverse permittivity tensor. A Fourier transform technique is employed to obtain integral expressions, in terms of solutions to this differential equation, for the field components in the three regions. An approximate method is used to evaluate the integrals and obtain results suitable for numerical computation. Two specific cases are considered, for the variation of the inverse permittivity tensor as a function of height, which lead to exact solution of the relevant differential equation. These solutions are utilized to approximate the variation with height as derived from model profiles of electron density and collision frequency for the ionosphere. In one case, the solution is expressed in terms of Whittaker's confluent hypergeometric function, while in the other case it is expressed in terms of the Hankel functions. It is found that the first case more closely approximates the actual behavior of the ionosphere while the second is easier to deal with numerically. Numerical results for the latter case are presented in the form of field-strength-versus-distance curves for several source locations. (Disser. Abstr.)

Low-Temperature Physics

Refer also to abstract 2289.

2966 (BNL-11901) SUPERCONDUCTIVE PHENOMENA IN ULTRA THIN FILMS. Strongin, Myron; Kammerer, O. F. (Brookhaven National Lab., Upton, N. Y.). [1967]. 22p. (CONF-671116-1). Dep. CFSTI.

From Applied Superconductivity Conference and Exhibition, Austin, Tex.

Work on the superconducting transition temperatures of ultra-thin films is reviewed. Some explanations for the change in T_c with respect to bulk materials are considered. An investigation of the possibility of electron pairing across dielectric barriers using superconductor-dielectric-superconductor layers is summarized. The preparation of the thinnest possible electrically continuous films, results of T_c measurements of these films, and possible explanations of the results are discussed. (A.G.W.)

2967 (NYO-3029-13) NATURE OF ac TRANSITIONS AND CRITICAL CURRENTS IN THE SUPERCONDUCTING SURFACE SHEATH. Report No. 596. Rollins, Roger William (Cornell Univ., Ithaca, N. Y. Materials Science Center). Feb. 1967. 150p. Dep. CFSTI.

Thesis.

The response of cylindrical type-II superconductors in the superconducting surface sheath state to an axial, low-frequency (10 to 1000 cps), small-amplitude (10^{-2} Oe < h_0 < 20 Oe) ac field superimposed on an axial dc field has been studied. Direct observation of the waveform representing the flux passing through the specimen shows that screening currents are developed in the sheath up to a critical value J_c when the field begins to penetrate. The screening current continues to increase until a saturation value J_s is reached at which point the current in the sheath stays constant for the remainder of the half cycle. For low exciting frequencies, J_s approaches J_c for perfect surface conditions. Fourier analysis of a model waveform for which $J_m = J_c = J_s$ indicates the harmonic content and nonlinear nature of the response. The model is interpreted simply in terms of free-energy diagrams for the superconducting sheath state based on a Ginzburg-Landau equivalent of the London fluxoid conservation concept. Measurements of the in- and out-of-phase components of the internal field, b(t), at the fundamental frequency, $b' = \mu' h_0$ and $b'' = \mu'' h_0$, as a function of the ac field amplitude at constant dc field show that the transition is characterized by only one parameter dependent on the dc field and that the proposed model gives an excellent description of the nonlinearity. The relationship between these observations and other measurements of the complex ac permeability, μ' and μ'', as a function of the dc field at constant ac field amplitude is discussed. The model is used to fit b' and b'' as a function of the ac field amplitude at various dc fields thus obtaining well defined critical-current data for comparison with the theories of Abrikosov, Park, and Fink and Barnes. The values obtained are, in general, much lower near H_{c3} than any of the theories predict. It is shown that the transition is very sensitive to misalignment of the specimen relative to the dc field and care is taken to ensure proper alignment. No size dependence of the critical current is observed. The frequency dependence of the transitions in the surface sheath are studied and interpreted in terms of finite lifetimes for the metastable current carrying states of the surface sheath. Energy is dissipated by the surface sheath during the course of transitions between metastable superconducting sheath states enclosing different numbers of fluxoids. (auth)

2968 ANOMALOUS GAPLESS SUPERCONDUCTIVITY DUE TO SCATTERING FROM LOCALIZED NONINTERACTING SPINS. Edelstein, Alan S. (IBM Watson Research Center, Yorktown Heights, N. Y.). Phys. Rev. Lett., 19: 1184-6(Nov. 13, 1967).

Electron-tunneling measurements made on lanthanum-cerium alloy films show large deviations from the Abriksov-Gor'kov theory of gapless superconductivity. It has been suggested that such deviations should occur for an alloy system such as cerium in lanthanum which exhibits resonant scattering. (auth)

2969 EVIDENCE OF NUCLEAR SPIN ORDERING IN SOLID ^{3}He. Panczyk, M. F.; Scribner, R. A.; Straty, G. C.; Adams, E. D. (Univ. of Florida, Gainesville). Phys. Rev. Lett., 19: 1102-5(Nov. 6, 1967).

Measurements of the pressure versus temperature for constant-volume samples of solid ^{3}He to 20 mdeg K show the expected T^{-1} dependence due to spin ordering at low temperatures. A value for the exchange integral $|J|/k$ of about 0.7 mdeg K is obtained for a molar volume of 24 cm^3, with $\partial \ln|J|/\partial \ln V = 16.4$. (auth)

2970 THERMALLY INDUCED He II VAPORIZATION THRESHOLD FOR SUPERCONDUCTING AND NORMAL LEAD. Frederking, T. H. K.; Hesser, R. J. (Univ. of California, Los Angeles). Phys. Lett., 25A: 666-7(Nov. 6, 1967).

The limiting heat current density at which vaporization is initiated in He II at a lead surface is shown to be a function of the liquid temperature without significant effects of the state of order in the solid. (auth)

2971 KONDO EFFECT IN SUPERCONDUCTING PROPERTIES OF MAGNETICALLY DILUTE ALLOYS. Sugawara, T.; Eguchi, H. (Tokyo Univ.). Phys. Lett., 25A: 668-9(Nov. 6, 1967).

Evidence is given for the existence of the Kondo effect in T_c and H_{c2} of dilute La-Ce and La-Gd alloys. (auth)

2972 MAGNETIC INDUCTION IN TYPE-II SUPERCONDUCTOR TUBES. Bode, H. J. (Siemens-Schuckertwerke AG, Erlangen, Ger.). Phys. Lett., 25A: 661-2(Nov. 6, 1967).

A measurement of the magnetic induction in the wall of a type-II superconductor tube prepared from Pb-In alloy clearly shows the validity of the Abrikosov or Fink model of magnetization. (auth)

2973 ATTEMPTS TO OBSERVE EXPERIMENTALLY THE PENETRATION OF SUPERFLUIDITY INTO NARROW PORES. Gamtselidze, G. A.; Dzhaparidze, Sh. A.; Turkadze, K. A. (Tbilisi State Univ., USSR). JETP Lett. (USSR) (Engl. Transl.), 6: 44-6(July 15, 1967).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu, 6: 517-21(July 15, 1967).

It is well known that superfluidity should vanish in narrow gaps at temperatures T_c whose positions below the λ point ($T_\lambda = 2.173°K$) are the lower, the smaller the gap width. However, it has been shown that if a sufficiently large volume of superfluid liquid flows around a microporous body, then the helium filling the pores of this body retains its superfluidity in the temperature interval $T_\lambda > T > T_c$. Results are reported of a preliminary set of experiments undertaken for the purpose of investigating these phenomena. (W.D.M.)

2974 CALCULATION OF THE SUPERCONDUCTING TRANSITION TEMPERATURE IN ALUMINIUM. Carbotte, J. P. (McGill Univ., Montreal); Dynes, R. C. Phys. Lett., 25A: 685-6(Nov. 6, 1967).

From inelastic neutron-scattering data on phonons and the Heine-Abarenkov pseudopotential for the electron-ion form factor the superconducting transition temperature in aluminum was calculated. (auth)

2975 THE EFFECT OF VERY THIN Ge COATING ON THE SUPERCONDUCTING TRANSITION OF THIN Sn AND Tl FILMS. Naugle, D. G. (Univ., Goettingen, Ger.). Phys. Lett., 25A: 688-90(Nov. 6, 1967).

The effect of the deposition of thin Ge coatings on thin Sn and Tl films is reported. T_c for Sn is reduced while T_c for Tl is increased. An anomalous increase in T_c for Tl appears for approximately a monolayer coating of Ge, which is interpreted as evidence for surface superconductivity. The decrease in T_c for Sn is attributed to the removal of electrons from the Sn to form the contact potential. (auth)

2976 STRONG-COUPLING SUPERCONDUCTIVITY IN AMORPHOUS BISMUTH. Chen, J. T.; Chen, T. T.; Leslie, J. D.; Smith, H. J. T. (Univ. of Waterloo, Can.). Phys. Lett., 25A: 679-80(Nov. 6, 1967).

Tunneling measurements indicate that amorphous bismuth is a strong-coupling superconductor with $2\Delta/k_B T_c = 4.60 \pm 0.05$, and show evidence of phonon structure in the dV/dI versus V curves. (auth)

2977 ANISOTROPY OF THE NIOBIUM ENERGY GAP BY A SINGLE-CRYSTAL TUNNELING TECHNIQUE. Macvicar, M. L. A.; Rose, R. M. (Massachusetts Inst. of Tech., Cambridge). Phys. Lett., 25A: 681-2(Nov. 6, 1967).

The energy gap for the simple crystallographic directions of superconducting Nb has been determined by a single-crystal tunneling technique. (auth)

2978 EVIDENCE FOR METASTABLE SUPERCONDUCTING SURFACE SHEATHS BELOW THE BULK CRITICAL FIELD. Smith, F. W.; Cardona, M. (Brown Univ., Providence). Phys. Lett., 25A: 671-2(Nov. 6, 1967).

The metastable existence of the superconducting surface sheath below H_c in decreasing fields has been observed in type-I superconductors with $0.39 \leq \kappa < 0.6$. This is evidence that the bulk material can supercool to a field $H_s < H_{c3}$. (auth)

2979 FLICKER NOISE IN THIN SUPERCONDUCTING FOILS. Van Der Ziel, A. (Univ., Stuttgart). Phys. Lett., 25A: 672-3(Nov. 6, 1967).

Flicker noise in superconducting foils is explained by a random modulation of the size or the number of vortex bundles moving through the foil. Both may be caused by a random modulation of pinning centers pinning the vortex bundles. (auth)

2980 SUPERCONDUCTING GRADE 65BT ALLOY. Elektrichestvo, No. 10, 82-3(1966). (In Russian).

The superconducting grade 65BT alloy, which contains 65% Nb, 25% Ti, and a number of other technologically important components, is melted in vacuum arc furnaces; it is then hot pressure treated and cold drawn. As a result of the high total deformation during drawing (exceeding 99%), a definite axial [110] texture and a fibrous structure are formed. If grade 65BT alloy wire is given an 0.01 to 0.025-mm-thick coating of copper, it can be effectively used in superconducting solenoids. It is coated 0.015 mm thick with a polyester varnish as dielectric insulation. The principal parameters of the wire are given: longitudinal critical magnetic field under pulsed conditions, 90 kergs; critical current density, (5 to 10) × 10^4 and (3.5 to 5) × 10^5 A/cm^2 with transverse magnetic fields of 20 and 60 kergs; elasticity is 1.24 × 10^4 kg/mm^2. Without the copper coating for insulation the wire costs 800 rubles/kg; with the copper coating and insulation it costs about 1300 rubles/kg. Superconducting solenoids for different fields between 20 and 76 kergs have been made of grade 65BT alloy, and are giving effective service. (Rev. Met. Lit.)

2981 THERMODYNAMICS OF ROTATING LIQUID He II. Pollock, F. (Stevens Inst. of Tech., Hoboken, N. J. Columbia Univ., Dobbs Ferry, N. Y.). Phys. Fluids, 10: 2312-14(Nov. 1967).

A thermodynamic calculation of the change in superfluid velocity with temperature is described. It is shown that (a) thermodynamics is compatible with a temperature-independent hydrodynamical criterion for superfluid flow, and (b) only discrete changes of superfluid velocities with the angular velocity of the container are consistent with thermodynamic equilibrium. (auth)

2982 LOCAL GAUGE INVARIANCE AND BROKEN SYMMETRY IN SUPERFLUID HELIUM. Sarfatt, J. (Univ. of California, San Diego). Phys. Lett., 25A: 642-3(Nov. 6, 1967).

Full Galilean invariance is restored to the Gross–Pitaevskii model of He II by the introduction of Yang–Mills transverse collective modes. (auth)

2983 THEORY OF SUPERCONDUCTING FERMI LIQUID WITH THE P PAIRING. Czerwonko, J. (Univ., Wroclaw). Acta Phys. Pol., 32: 335-58(1967).

The theory of superconducting Fermi systems with the P pairing is developed. No decoupling procedure is assumed for the Green's functions and, similarly, it is not assumed that the system is described by a model Hamiltonian. The assumption that the energy gap is much less than the Fermi energy is the most important assumption. A similar theory for systems with S pairing was developed by Larkin and Migdal (1963) by generalization of the theory of normal Fermi liquid given by Landau (1958). In the present paper the general solutions for static spin susceptibility and for vertex functions if the energy and momentum transfers are small are obtained. The poles of vertex functions give energies of collective excitations. The dispersion curve for the acoustic branch of excitations is the same as for systems with S pairing and is given by the thermodynamical formula. From the expression for vertex functions the polarization operator giving the gauge-invariant Meissner effect is obtained. The expression for static spin susceptibility can be used to obtain the relation between Landau parameters with the use of the experimental data for Knight's shift. (auth)

2984 PULSE MEASUREMENTS ON SUPERCONDUCTING MEMORY CELL LAYERS. Goser, Karl (Siemens-Schuckertwerke AG, Munich). Arch. Elek. Uebertrag., 21: 535-46(Oct. 1967). (In German).

On superconducting continuous film memory cells the shortest cycle time and the operating range are determined by experiment. The cycle time is not limited by the switching operation, but by the heating. Cycle times less than 1 μs are only attained when substrates of good thermal conductivity are employed. The working range of each memory cell must at least equal the spread of the operating parameters on a matrix, to allow all memory cells to be driven with pulses of the same current intensity. On the investigated matrices the spread was about ±12%; the experimentally determined working range usually is smaller than the theoretical value of ±14%. Unless different cell types are used, the production of operable memory matrices will therefore require a refined technology. The experimental results are discussed by reference to an electrical equivalent circuit which results from a simple model concept for the mode of functioning of the film-type memory cell. (auth)

2985 EFFECT OF H_{c1} ON AC LOSSES IN NIOBIUM. Easson, R. M.; Hlawiczka, P. (Univ., Glasgow). Phys. Status Solidi, 23: K129-36(Oct. 1, 1967).

Ac power loss measurements were carried out on as-machined and as-rolled Nb before and after surface treatment. The treatment was found to increase the field at which losses appear. For the smoothest samples, losses are not observable below ~1400 Oe, in agreement with H_{c1} = 1410 Oe. A plot of the temperature dependence of the field also agrees with that for H_{c1}. (D.L.C.)

2986 STUDY OF LEAD–TIN EUTECTIC SUPERCONDUCTORS WITH ORIENTED LAMELLAE. Dobrosavijevic, L.; Dupuis, C. (Faculte des Sciences, Orsay, France). Phys. Status Solidi, 23: 509-20(Oct. 1, 1967). (In French).

A study is made of the magnetic properties of lamellar Pb–Sn eutectic, with the magnetic field H in the plane of the lamellae. The surface permeability is measured at radio frequencies, which permits a study solely of the surface. The thickness of the lamellae is generally much greater than the coherence length. Under these conditions, as soon as the static field H is greater than the critical field of Sn, the flux penetrates the Sn lamellas. The area of the lamella through which the flux penetrates can be written in the form $\delta \times 2(d - \rho)$, where δ is the diameter of the particles, 2d the thickness of the Sn lamellae, and ρ a correction due to proximity effects. The experimental magnitude of ρ and its variation with T and H are in qualitative agreement with theory. A quantitative comparison is complicated by atomic migration effects at the interfaces, which lead, in particular, to aging phenomena. (auth)

2987 FINE STRUCTURE OF THE VOLT–AMPERE CHARACTERISTICS OF JOSEPHSON TUNNEL JUNCTIONS IN Sn–Pb. Yanson, I. K. (Physical-Technical Inst. of Low Temperatures, Kharkov). Zh. Eksp. Teor. Fiz., 53: 1268-73(Oct. 1967). (In Russian).

The volt–ampere characteristics and their first and second derivatives are studied for Josephson tunnel junctions from thin tin and lead films. It is shown that the constant current component is related to absorption of Josephson electromagnetic radiation in the junction. The features observed are interpreted as threshold effects of radiation absorption in anisotropic Sn and Pb. (auth)

2988 RELAXATION ABSORPTION OF ELECTROMAGNETIC WAVES BY A SUPERCONDUCTOR. Kemoklidze, M. P. (Inst. of Physical Problems, Moscow). Zh. Eksp. Teor. Fiz., 53: 1362-70(Oct. 1967). (In Russian).

The high-frequency surface impedance of a pure superconductor in a stationary magnetic field near the transition point is calculated. It is shown that for low frequencies $\omega_0 \ll \Delta^2/T_c$ an additional absorption $\sim\omega_0 \ln^2\omega_0$ exists, which is related to relaxation of the gap Δ. (auth)

2989 THERMAL CONDUCTIVITY OF SUPERCONDUCTORS IN THE INTERMEDIATE STATE. Shikin, V. B. (Physical-Technical Inst. of Low Temperatures, Kharkov). Zh. Eksp. Teor. Fiz., 53: 1431-3(Oct. 1967). (In Russian).

It is shown that for $T \ll T_c$ and superconducting and normal layer thicknesses $a_s \ll a_n$ the thermal resistance of the intermediate state of superconductors is mainly determined by tunneling of thermal excitations through s layers but not by jumps over the barrier. (auth)

2990 DYNAMICS OF THE INTERMEDIATE STATE IN SUPERCONDUCTORS. Andreev, A. F.; Sharvin, Yu. V. (Inst. of Physical Problems, Moscow). Zh. Eksp. Teor. Fiz., 53: 1499-1504(Oct. 1967). (In Russian).

A macroscopic description of the dynamic lamellar structure of the intermediate state of superconductors in nonstationary external conditions or in the presence of a constant current is proposed. The case of a current-carrying plane-parallel plate located in a perpendicular magnetic field is considered in detail. (auth)

2991 NUCLEATION OF THE SUPERCONDUCTING PHASE. Rachinger, W. A. J. Aust. Inst. Metals, 11: No. 4, 231-4(Nov. 1966).

It is shown that the superconducting state is an ordered electron state which can be destroyed either by an increase in temperature or by the application of a sufficiently strong magnetic field. Thermodynamic considerations lead to the Ginsburg–Landau equations and these may be used to study nucleation of the superconducting phase. Nucleation and growth of the superconducting phase depend on the geometry of the specimen and its surface condition. Since the superconducting state is characterized by zero electrical resistance and partial or complete exclusion of magnetic flux, either of these features may be used to detect nucleation. (Rev. Met. Lit.)

2992 EXPERIMENTAL INVESTIGATION OF THE LAMBDA TRANSITION OF LIQUID HELIUM USING ACOUSTIC TECHNIQUES. Barmatz, Martin Bruce. Los Angeles, Univ. of California, 1966. 114p.

Thesis.

The velocity and attenuation of first sound have been measured to within microdegrees of the lambda transition of liquid helium. Measurements were made in the frequency range of 20 to 100 kc in order to reduce the effects of dispersion found in earlier investigations. A technique was developed to continuously monitor the velocity of sound and attenuation simultaneously as the resonator drifted through the transition. With the high Q modes of the resonator, relative sound velocity measurements of one part in 10^8 could be obtained. Above the transition the velocity of sound had the temperature dependence predicted by the Pippard theory out to 5 millidegrees from the lambda point. The velocity of sound below the transition doesn't agree with the Pippard theory except within a fraction of a millidegree of the transition. The added temperature dependence beyond that expected from the Pippard theory can be fit to a series expansion in $|\Delta T|$. This additional dependence is postulated to be due to the effects of the order parameter. The data of this experiment indicate that the results above and below the transition approach a common value at the lambda point. The minimum of the sound velocity at the lambda point was found to be finite and equal to 217.05 m/s. Using the convective properties of the resonator, the position of the density maximum was found to be approximately 6.2 millidegrees above the lambda point. The following values have been determined at the lambda point: $(dP/dT)_\lambda = -120.5$ atm. $°K^{-1}$, $(dS/dP)_\lambda = -2.25 \times 10^{-2}$ Joules atm^{-1} gm^{-1} $°K^{-1}$, $(dv/dT)_\lambda = 11.9$ cm^3 gm^{-1} $°K^{-1}$. The attenuation measured below the transition was proportional to $|T - T_\lambda|^{-1}$, which is in agreement with the Landau–Khalatnikov theory. Above the transition the temperature dependence of the attenuation was found to be $|T - T_\lambda|^{-\frac{1}{2}}$. (Disser. Abstr.)

2993 VERIFICATION OF LONG-RANGE QUANTUM PHASE COHERENCE IN SUPERCONDUCTING TIN UTILIZING ELECTROMAGNETICALLY STABILIZED JOSEPHSON JUNCTIONS. Vant-Hull, Lorin Lee. Pasadena, Calif., California Inst. of Tech., 1967. 87p.

Thesis.

de Broglie-wave interferometers were constructed, successfully utilizing extended superconducting links of tin to couple coherently the quantum phases of two Josephson junctions. The current transmitted by these devices was periodic in the enclosed flux (periodicity $(.9 \pm .3)h/2e$) demonstrating unambiguously coherence of the superconducting order parameter over 1.33 meters. A "normal" Josephson junction may be defined as one for which the quantum mechanical coupling energy is insufficient to overcome the disruptive effects of noise. Consequently, the relative phase of the coupled superconductors is not stabilized and the "zero voltage" Josephson current fluctuates, (bandwidth $\sim 2eV_{noise}/h$) averaging to zero. Two such "normal" junctions have been coupled to an electromagnetic cavity formed by the superconducting arms of a quantum interferometer (junction separation 1.33 meters). With an applied steady voltage such that the Josephson current excites a normal mode of the cavity, a coherent radiation field is built up. This coherent radiation feeds back to the functions forcing time coherence on the phase precession, resulting in a dynamic stabilization of the junctions. Under these conditions a series of "constant voltage steps" has been observed in the I–V characteristic of one interferometer. The Josephson frequency associated with these steps is shown to be characteristic of the electromagnetic resonant modes of the cavity. Frequency modulation analysis, combined with a detailed analysis of the cavity-junction combination, predicts such maxima in the tunneling of pairs when a "selection rule," $(m + n)$ even, is obeyed. Here $m/2$ is the number of flux quanta $(h/2e)$ linking the interferometer and n is the order of the cavity resonance excited. Experimental confirmation of the detailed predictions of the analysis is presented. (Disser. Abstr.)

2994 NATURE OF ac TRANSITIONS AND CRITICAL CURRENTS IN THE SUPERCONDUCTING SURFACE SHEATH. Rollins, Roger William. Ithaca, N. Y., Cornell Univ., 1966. 164p.

Thesis.

The response of cylindrical type-II superconductors in the superconducting surface sheath state to an axial, low-frequency (10 to 1000 cs), small amplitude (10^{-2} Oe < h_0 < 20 Oe) ac field superimposed on an axial dc field has been studied. Direct observation of the waveform representing the flux passing through the specimen shows that screening currents are developed in the sheath up to a critical value J_c when the field begins to penetrate. The screening current continues to increase until a saturation value J_s is reached at which point the current in the sheath stays constant for the remainder of the half cycle. For low exciting frequencies, J_s approaches J_c for perfect surface conditions. Fourier analysis of a model waveform for which $J_m = J_c = J_s$ indicates the harmonic content, and nonlinear nature, of the response. The model is interpreted simply in terms of free energy diagrams for the superconducting sheath state based on a Ginzburg–Landau equivalent of the London fluxoid conservation concept. Measurements of the in and out of phase components of the internal field, b(t), at the fundamental frequency, $b' = \mu' h_0$ and $b'' = \mu'' h_0$ as a function of the ac field amplitude at constant dc field shows that the transition is characterized by only one parameter dependent on the dc field and that the proposed model gives an excellent description of the nonlinearity. The relationship between these observations and other measurements of the complex ac permeability, μ' and μ'', as a function of the dc field at constant ac field amplitude is discussed. The model is used to fit b' and b'' as a function of the ac field amplitude at various dc fields thus obtaining well defined current data for comparison with the theories of Abrikosov, Park and Fink and Barnes. The values obtained are, in general, much lower near H_{c3} than any of the theories predict. It is shown that the transition is very sensitive to misalignment of the specimen relative to the dc field and care is taken to ensure proper alignment. No size dependence of the critical current is observed. The frequency dependence of the transitions in the surface sheath are studied and interpreted in terms of finite lifetimes for the metastable current carrying states of the surface sheath. Energy is dissipated by the surface sheath during the course of transitions between metastable superconducting sheath states enclosing different numbers of fluxoids. (Disser. Abstr.)

2995 TUNNELING INTO SUPERCONDUCTORS IN A MAGNETIC FIELD. Millstein, Jerry. Berkeley, Calif., Univ. of California, 1966. 60p.

Thesis.

Tunneling experiments were performed on thin superconducting films in the presence of a magnetic field. The experiments were done at ^{3}He temperatures on tin and tin–indium alloy films with thicknesses between 600 and 2000 Å. The effect of the field on the density of states is, for dirty films, similar to the effect of paramagnetic impurities. The square of the magnetic field plays a role analogous to the paramagnetic impurity concentration. The data are compared to the results of Skalski et al., and agreement is fair. The difference between their results and this experiment is attributed to mean free path effects. Wyder and Strassler have calculated the field dependence of the density of states for films with arbitrary mean free path. It is found that their calculations are in good agreement with experiment. (Disser. Abstr.)

2996 CRITICAL MAGNETIC FIELD OF SUPERCONDUCTING TIN FILMS. Harper, Francis Edward. Berkeley, Calif., Univ. of California, 1966. 94p.

Thesis.

The magnetic behavior of vacuum evaporated clean tin films ($l_0 > d$) and dirty tin films ($l_0 < d$) was studied in the superconducting state; l_0 is the mean free path for volume scattering and d is the thickness of the film. When a magnetic field is applied at an arbitrary angle to the surface of a sufficiently thin film ($d \lesssim 1000$ Å), the critical field, $H_c(\theta)$, was found to satisfy $(H_c(\theta) \cos\theta/H_{c\parallel})^2 + [H_c(\theta) \sin\theta/H_{c\perp}] = 1$ where $H_{c\parallel}(t) = [\sqrt{24}\lambda(t)H_{cb}(t)/d]$ and $H_{c\perp}(t) \approx [4\pi\lambda^2(t)H^2_{cb}(t)/\varphi_0]$, $\lambda(t)$ is the penetration depth, $H_{cb}(t)$ is the thermodynamic critical field, $t = T/T_c$ is the residual temperature, and φ_0 is the flux quantum. The dependence of the critical field on volume scattering and on film geometry is contained in $\lambda(t)$. According to a suggestion made by Tinkham $\lambda(t)$ is related to d and l_0 according to $\lambda(t) = \lambda_L(t)\sqrt{1 + \eta\ (\xi_0/d) + (\xi_0/l_0)}$ where $\lambda_L(t)$ is the London penetration depth, ξ_0 is the Pippard coherence length and η is a constant which was determined experimentally to be $\eta \approx \frac{1}{2}$. These results are consistent with a theory due to Tinkham based on the Ginzburg–Landau theory of superconductivity and valid for films whose thickness is less than the temperature dependent coherence length, ξ_T, introduced by de Gennes. For thicker films ($d \gtrsim 1000$ Å) it is necessary to extend Tinkham's initial theory to explain the present experimental results. Extensions of Tinkham's initial theory made by Tinkham, Saint-James, de Gennes, and Yamafuji, et al., are consistent with experimental results for thick films obtained here. As a result of the general agreement between the experiments and theory, it is concluded that the behavior of a superconducting film in a magnetic field is well described by the Ginzburg–Landau theory for temperatures near the transition temperature and for applied magnetic fields near the critical field. An important consequence of this theory (for which the experiments gave only indirect evidence) is that in a perpendicular magnetic field the Abrikosov vortex

state exists in a clean thin film with $H_{c1} < H_{cb}$ as well as in a dirty thin film with $H_{c1} > H_{cb}$. (Disser. Abstr.)

2997 METHOD FOR IMPREGNATING SUPERCONDUCTING MAGNETIC COILS. Bonnin, Bernard; Weil, Louis (to Commissariat a l'Energie Atomique). British Patent 1,089,580. Nov. 1, 1967. Priority date Apr. 21, 1965, France.

A method is described for introducing a heterogeneous impregnating mixture between the successive turns of a wire in the process of being wound into a coil. The mixture, containing a granulated material having a Young's modulus of at least 11.38×10^6 lbs/in.^{2} is viscous while the wire is being wound and is brought to the solid state by the application of low temperatures. (J.H.M.)

Plasma and Thermonuclear Physics

Refer also to abstract 2266.

2998 (AED-C-03-11) DOCUMENTATION OF PLASMA PHYSICS. PART 1. EXPERIMENTAL PLASMA PHYSICS THEORETICAL PLASMA PHYSICS. Bibliography; Author Index; Subject Index. Volume 2. Hilsenbeck, D. (Zentralstelle fuer Atomkernenergie-Dokumentation, Frankfurt am Main (West Germany)). Aug. 1967. 194p. Dep.

A listing of 360 papers on various aspects of plasma physics is presented. Subject and author indexes are included. (M.O.W.)

2999 (AED-C-03-12) DOCUMENTATION OF PLASMA PHYSICS. PART 1. EXPERIMENTAL PLASMA PHYSICS THEORETICAL PLASMA PHYSICS. BIBLIOGRAPHY, AUTHOR INDEX, SUBJECT INDEX. VOLUME 2. Hilsenbeck, D. (Zentralstelle fuer Atomkernenergie-Dokumentation, Frankfurt am Main (West Germany)). Sept. 1967. 59p. Dep.

A listing of 341 papers on various aspects of plasma physics is presented. Subject and author indexes are also included. (M.O.W.)

3000 (SU-IPR-190) BIBLIOGRAPHY OF STANFORD REPORTS, PAPERS, AND CONFERENCE PRESENTATIONS ON PLASMA PHYSICS. (Stanford Univ., Calif. Inst. for Plasma Research). Revised July 1967. 65p. Dep. CFSTI.

Approximately 550 articles are included in the listing. An author index is included. (M.O.W.)

3001 ACCURACY OF CALCULATING THE SCALAR ELECTRICAL CONDUCTIVITY AT VERY LOW IONIZATION LEVELS. Schweitzer, S. (Univ. of Pennsylvania, Philadelphia). AIAA (Amer. Inst. Aeronaut. Astronaut.) J., 5: 2086-7(Nov. 1967).

The general validity of mixture rules for calculating the electric conductivity of a partially ionized plasma has been examined for arbitrary electron–neutral cross sections and for a model gas having an electron–neutral collision frequency of the form $\nu_{en}(g) \alpha g^{2m}$ where g is the relative electron speed and m is a parameter. Using the third Chapman–Enskog approximation, it is shown that within the uncertainties in the experimental electron–neutral cross section values, Frost's mixture rule for the scalar electric conductivity offers a satisfactory method of calculation for most engineering problems. (auth)

Confinement and Heating of Plasma

3002 (INR-836/XVIII/PP) PLASMA CONFINEMENT WITH SPHERICAL MULTIPOLE MAGNETIC FIELD. Sadowski, Marek (Institute of Nuclear Research, Warsaw (Poland)). 1967. 6p. Dep.

The possibility of application of a spherical high-order multipole as a plasma magnetic trap is considered and various spherical multipoles are described. The approximate formula for particle losses from the icosahedron-geometry trap, as well as comments on the experimental arrangement realized, are given. (auth)

3003 (IPP-1/71) ELEKTRONISCHE HILFSGERAETE FUER DIE 2,6 MJ-BATTERIE. (Electronic Auxiliary Devices for the 2,6 MJ Theta Pinch). Seidel, U. (Institut fuer Plasmaphysik, G.m.b.H., Garching (West Germany)). Sept. 1967. 14p. (In German). Dep.

Electronic circuits are described, developed for the purpose of safe handling and controlling mega-joule theta pinches. In case one or several spark-gaps of the condenser bank break down prematurely, uncontrolled triggering of other spark gaps is likely to occur; this might bring damage for part of the condenser bank. To prevent this a circuit was developed which automatically fires the whole bank if any spark gaps break down prematurely. This device also registers these groups of the bank where uncontrolled breakdown occurred. Another circuit was designed to control different functions of a series of oscilloscopes (Tektronix Type 551). It can give a "reset pulse" to a prefixed number of oscilloscopes, it can make a selected number of scopes write a bottom line, and it shows if all oscilloscopes are in the "ready state." The main advantage of this device is that all oscilloscopes are controlled from one unit. A circuit for a Tektronix 1A1 plug-in unit is given, which allows two independent simultaneous signals on a single trace up to a deflection speed of 0.1 μsec/cm to be written, without influencing the signal-to-noise ratio. (auth)

3004 (TID-24139) MAGNETIC PUMPING FOR THE MODEL C STELLARATOR. Tech. Memo. No. 173. Gottlieb, M. B. (Princeton Univ., N. J. Plasma Physics Lab.). Apr. 1963. Contract AT(30-1)-1238. 27p. Dep. CFSTI.

The magnetic pumping system planned for the Model C stellarator is described. The parameters of the Model C system are given, after which the theoretical expectations are calculated. The status of each component is given, together with cost and time estimates for completion. (M.O.W.)

3005 (UCRL-Trans-1358) EXPERIMENTAL INVESTIGATION OF THE MOTION OF SINGLE CHARGED PARTICLES IN A TRAP WITH MAGNETIC MIRRORS. Ponomarenko, V. G.; Trainin, L. Ya.; Yurchenko, V. I.; Yasnetskii, A. N. (Akademiya Nauk SSSR, Novosibirsk. Institut Yadernoi Fiziki). Translated by M. Kassatkin (Univ. of California, Lawrence Radiation Lab., Berkeley), from a Preprint. 21p. Dep. CFSTI. JCL $2.60 fs, $0.83 mf.

Experiments to detect the nonadiabatic escape of electrons from a trap are described. It was established that there exists an area of motion in which the nonadiabatic effects are manifested most intensively. The values characterizing the motion processes which were found from the evaluation of the experimental results depend, in a complex way, on the parameters of the experiment. The method described for measuring the time dependence of the distribution by magnetic moments can be applied when variable fields are present in the working volume. In this case it is necessary to determine by some means the energy distribution of the electrons ejected by the second pulse. (auth)

3006 STOCHASTIC DESTRUCTION OF STELLARATOR MAGNETIC SURFACES. Chirikov, B. V. Dokl. Akad. Nauk SSSR, 174: 1313-16(June 21, 1967). (In Russian).

The "behavior" of force lines in an accelerator is analogous to the movement of a nonlinear accelerator due to the average spiraling angle $\omega(r)$ of the force lines on a small radius r. Although the nonlinearity stabilizes resonance perturbations, it also leads to the appearance of new instabilities, the most dangerous of which is the stochastic instability. In this instability the force lines distribute themselves in a random fashion, and rapidly leave the confines of the plasma. The motions of the magnetic force lines in the main field, and the perturbations are described by the following equations: (1) $ds/dz = 2\epsilon n s^{0.5n} \sin n\theta$; $\theta = \varphi - \alpha z$; $s = (r/a)^2$; $d\varphi/dz = \epsilon n s^{0.5n-1} \cos n\theta$; $\epsilon a = 4I/caH_z$. Here n is the number of field turns with step $2\pi/\alpha$; a is the radius of the cylinder carrying 2n conductors with a current I in each conductor; H_z is the longitudinal field; r, φ and z are cylindrical coordinates. The equations are valid at ϵa and $s \ll 1$. Due to the periodicity, the perturbation can be described by difference equations which are replaced by differential equations describing a nonlinear resonance. The parameters of the stochastic region are defined, and it is found that the "movement" of the force lines is diffusional in character in this region. The stochastic instability of the force lines can be used to create a trap, inside of which there is a turbulent or stochastic region surrounded by a laminar region of regular magnetic surfaces. The design leads to a relatively long stellarator. The turbulent region of the magnetic field may suppress other plasma instabilities. (TTT)

3007 TURBULENT HEATING OF PLASMA IN A MIRROR. Jensen, T. H.; Scott, F. R. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). Contract DA-49-146-XZ-534. Phys. Rev. Lett., 19: 1100-2(Nov. 6, 1967).

A plasma has been heated substantially by passing a current through it. The plasma was injected axially into a mirror field, and the current was passed through the plasma parallel to the magnetic field. A heating efficiency was obtained, insensitive to variations of the discharge-circuit parameters as well as the density of the initial plasma, of 3 to 4%. (auth)

3008 PLASMA CONFINEMENT WITH SPHERICAL MULTIPOLE MAGNETIC FIELD. Sadowski, M. (Inst. of Nuclear Research, Swierk, Poland). Phys. Lett., 25A: 695-6(Nov. 6, 1967).

The possibility of application of a spherical high-order multipole as a plasma magnetic trap is considered and various spherical multipoles are described. The approximate formula for particle losses from the icosahedron-geometry trap as well as comments on the experimental arrangement realized are given. (auth)

3009 CHARGED PARTICLE DIFFUSION BY VIOLATION OF THE THIRD ADIABATIC INVARIANT. Birmingham, T. J. (Goddard Space Flight Center, Greenbelt, Md.); Northrop, T. G.; Falthammar, C.-G. Phys. Fluids, 10: 2389-98(Nov. 1967).

An equation which describes statistically the motion of charged particles in response to fluctuating electric and magnetic fields is derived. The particles are assumed to be moving in a mirror-type magnetic geometry. In addition to a static magnetic field there are small superposed fields fluctuating randomly on such a time scale that the first and second adiabatic invariants, M and J, are conserved, but the third or flux invariant Φ is violated. By using second adiabatic theory a two dimensional diffusion equation is obtained valid on a much longer time scale than that of the fluctuations. Elements of the diffusion tensor are time–space correlations of fluctuation-induced perturbations in the guiding center drifts. These drift perturbations are systematically derived and shown to reduce simply in various special cases. (auth)

3010 ULTRA-FAST THETATRON PINCH EXPERIMENT. Adlam, J. H.; Burcham, J. N. (United Kingdom Atomic Energy Authority, Abingdon, Eng.). Phys. Fluids, 10: 2458-65(Nov. 1967).

A power supply consisting entirely of coaxial lines was used to produce a current pulse of 100-nsec duration in a thetatron coil, the plasma inside the coil being preionized. Measurements were made of the magnetic field, using magnetic probes, and of x rays produced. These measurements showed that, under suitable conditions, shock waves were produced and the electrons were heated to a temperature of several thousand electron volts. A necessary condition for producing an electron temperature approaching that required by shock theory was that the magnetic field outside the plasma should be in the opposite direction to the magnetic field inside the plasma. (auth)

3011 SYMMETRIC EQUILIBRIUM PLASMA CONFIGURATIONS. Yurchenko, E. I. Zh. Tekh. Fiz., 37: 1458-9(Aug. 1967). (In Russian).

Calculations by V. D. Shafranov of the equilibrium pressure distribution in plasma filaments in machines of the Tokamak and figure eight types are reexamined with regard to the range of pressures for which the results are valid. The reexamination was undertaken because the expansion parameter employed in the calculations involves not only the curvature of the plasma filament (which is assumed to be small), but also the pressure. It is shown that if linear relations obtain between the pressure and certain potentials describing the magnetic field, the second and higher order terms in the expansion of the potential may be small even when the first order term is nearly as large as the zeroth order one. Use is made of this result in a very brief discussion of the equilibrium pressure distribution in a toroidal and a helical plasma filament with a circular cross section. It is found that the magnetic axis is shifted from the center of the cross section of the plasma filament in the direction away from the center of curvature of the filament. (ATD)

3012 EQUILIBRIUM OF PLASMA IN A TRIPLE-WOUND STELLARATOR WITH A CIRCULAR MAGNETIC AXIS. Yurchenko, E. I. Zh. Tekh. Fiz., 37: 1460-5(Aug. 1967). (In Russian).

The method of Mercier (Nucl. Fusion, 3: 89(1963)) was used to derive approximate analytic equations for the magnetic surfaces of a triple-wound stellarator containing plasma. It is noted that the numerical calculations of Greene and Johnson (Phys. Fluids, 5: 531(1962)), gave circular cross sections for the vacuum magnetic surfaces, whereas the true cross sections should be more like equilateral triangles with rounded vertices. For the present calculations the vacuum magnetic field is assumed to be the gradient of the potential $Bz + (B/3)r^3Qh\sin(3\Theta - 3hz)$, where B is the strength of the toroidal magnetic field produced by the solenoid, Q and h are constants, and r, Θ, and z are quasi-cylindrical coordinates: r is the distance from the circular magnetic axis, Θ is the azimuthal angle about this axis, and z is the distance measured along the circular magnetic axis. The current in a plasma with a given pressure distribution in equilibrium in this field is calculated with the aid of the equilibrium magnetohydrodynamic equations under the assumption that the total longitudinal current between any magnetic surfaces is zero. The correction to the vacuum field due to these plasma currents is calculated, a definite expression being assumed for the plasma pressure distribution. Finally, the perturbed magnetic surfaces are calculated. In this calculation the relevant quantities are expanded in powers of r and the plasma pressure, and only the linear terms are retained, and it is assumed as a boundary condition that the magnetic surface at a certain (arbitrary) distance from the axis remains unperturbed. As an example, the vacuum and perturbed magnetic surfaces are shown graphically for one set of parameter values. It is concluded that the magnetic surfaces of a stellarator are strongly distorted as a result of the presence of plasma in the machine. (ATD)

3013 MEASUREMENT OF ELECTRON TEMPERATURES PRODUCED BY COLLISIONLESS SHOCK WAVES IN A MAGNETISED PLASMA. Paul, J. W. M.; Goldenbaum, G. C.; Iiyoshi, A.; Holmes, L. S.; Hardcastle, R. A. (United Kingdom Atomic Energy Authority, Abingdon, Eng.). Nature (London), 216: 363-4(Oct. 28, 1967). (CLM-P-142).

Measurements are reported on the shock heating of electrons resulting from the propagation of collisionless shock fronts through a highly ionized plasma in a direction perpendicular to an initial magnetic field. Direct measurements of electron temperature, made by Thomson scattering of laser light, were made with the view of verifying two previous inferences: (a) that the shocks cannot be explained in terms of binary transport coefficients, (b) that the electron heating, with negligible ion heating, satisfies the conservation relations across the shock for Alfvén Mach number $M_A \leq 3.7$. In the experiments performed the shock front, driven by the fast compression of a linear Z-pinch, propagated radially inwards with velocity $V_S = 2.5 \times 10^7$ cm/sec. through an initial hydrogen plasma, with electron density $\sim 7 \times 10^{14}$ cm^{-3} and temperatures ~/ev, in various initial axial magnetic fields, and a 400 MW, 20 nsec. pulse from a ruby laser was passed across the diameter of the discharge tube at the midplane. The scattered light was detected by a photomultiplier, and its spectral profile obtained using interference filters. The profile, resulting from Doppler broadening by the electrons, fitted a Gaussian curve to within ±15%. Three different types of shock structure were observed as M_A was increased by decreasing the initial magnetic field. At low $M_A(<3)$ the shock transition was sharp, whilst at high $M_A(<6$ it was more than ten times broader. At intermediate $M_A(\sim 3.7)$ a double structure was evident with the sharp transition preceded by the broad transition. The measured electron temperatures for $M_A = 2.5$ and 3.7 are shown as a function of time, relative to the sharp transition. For $M_A = 3.7$ the change of magnetic field is plotted to show the measurement of electron temperatures within the broad transition. The electron temperatures are compared with theoretical predictions of the total shock heating, derived independently of the shock mechanism, with good agreement between the measured temperatures immediately behind the shock for $M_A = 2.5$, verifying the inference that the ions are not appreciably heated in this case. For $M_A = 3.7$, however, this was not the case, allowing the possibility of some ion heating. The possibility of temperature limitation by end effects or impurities was investigated by an experiment performed in deuterium. Temperature limitations were ruled out. The measured electron temperatures were in all cases many times greater than calculated from the observed structure assuming binary resistivity. It was demonstrated that appreciable collisionless electron heating occurred in all shocks. For the low M_A shock the most probable mechanism is the excitation of plasma waves by electron–ion streaming instabilities in the high current density of the sharp transition. The subsequent interaction and damping of these waves can heat the electrons. At present there is no satisfactory interpretation of the observed high M_A shocks. (TSS) (UK)

3014 NONUNIFORM PROPAGATION OF IMPLODING SHOCKS AND DETONATIONS. Lee, B. H. K. (McGill Univ., Montreal). AIAA (Amer. Inst. Aeronaut. Astronaut.) J., 5: 1997-2003(Nov. 1967).

The self-propagating nature of imploding shock waves is considered by extending the similarity solution to earlier times in the implosion process when the shock strength is finite. Using Oshima's quasi-similar approximation, the equations of motion are reduced to a single first-order, nonlinear ordinary differential equation in Sedov's Z–V plane. It is shown that a singular characteristic exists for finite-strength shock waves. For each local Mach number a unique mathematical solution is obtained by assuming the flow to be regular on the singular characteristic following behind the shock. The quasi-similar method is also applicable to detonation waves since the departure from similarity due to heat release at the wave front is equivalent to counterpressure effects in shock waves. For both shocks and detonations, it is found that as the wave strengthens due to the effects of area convergence, the quasi-similar solution approaches the similarity solution asymptotically. In the limit, when the shock strength is infinite, these two solutions are identical. The quasi-similar method is checked against various approximate methods and very satisfactory agreement is obtained. The nonsimilar velocity distributions are found to exhibit the same behavior as those calculated by Payne using a numerical finite-difference method. Thus Oshima's method seems to be better suited for implosion than explosion problems. (auth)

Diagnostics of Plasma

3015 (IPP-1/58) EIN 90°-LASER-STREUEXPERIMENT ZUR MESSUNG VON TEMPERATUR UND DICHTE DER IONEN UND ELEKTRONEN EINES KALTEN, DICHTEN THETA PINCH PLASMAS. (A 90° Laser Scattering experiment for Measuring Temperature and Density of the Ions and Electrons in a Cold Dense Theta Pinch Plasma). Roehr, H. (Institut fuer Plasmaphysik, G.m.b.H., Garching (West Germany)). Aug. 1967. 39p. (In German). Dep.

Temperature and density of the ions and electrons were determined from the ion line in a 90° laser scattering experiment. In some cases the plasma data were chosen so that only two particles are contained in the Debye volume. Though the scattering theory is derived for the case of many particles in the Debye volume, no deviation from the calculated spectra could be observed. The values of the electron density were confirmed by measurements of the satellite peaks. (auth)

3016 (IPP-3/58) DER HEUTIGE STAND DER UNTERSUCHUNGEN ELEKTROMAGNETISCH ERZEUGTER INSTATIONARER STOSSWELLEN. (The Present Status of Investigations of Electromagnetically Produced Nonstationary Shock Waves). Muntenbruch, H. (Institut fuer Plasmaphysik, G.m.b.H., Garching (West Germany)). Apr. 1967. 35p. (In German). Dep.

Fast shock waves in light gases can be simply produced by electromagnetic acceleration. Unlike rail spark gaps or magnetic annular tubes, which produce quasi-stationary shock-wave-like phenomena, T tubes and conical theta pinches or z pinches generate nonstationary shock waves of the blast-wave type, if the plasma of the driving discharge does not advance right into the shock front and appreciably influence the plasma formed there. This paper is not so much a survey of investigations of the many variations of the driver systems mentioned above but deals rather with investigations of free-running shock waves and the distributions of the parameters in the plasmas behind these shock fronts. Shadowgraphs, interferograms, microwave interferograms and probe measurements have afforded a fairly complete picture of such nonstationary waves that reveals their uses and limitations. (auth)

3017 (IPP-3/59) ELECTRICAL CONDUCTIVITY IN ARGON POTASSIUM AND HELIUM POTASSIUM PLASMAS WITH ELEVATED ELECTRON TEMPERATURES IN CROSSED ELECTRIC AND MAGNETIC FIELDS. Brederlow, G.; Hodgson, R. (Institut fuer Plasmaphysik, G.m.b.H., Garching (West Germany)). Sept. 1967. 29p. Dep.

Methods and results of measurements of the tensor conductivity and electron temperature in argon–potassium and helium–potassium plasmas with elevated electron temperatures under MHD generator conditions are described. Electrode and wall effects that would make the measurements more difficult to interpret have been eliminated. Calculations of W. Feneberg predict that the scalar electrical conductivity should drop slightly with increasing magnetic field strength. However, the measured effective scalar conductivity was less than the theoretically predicted value. The discrepancy is apparently due to instabilities; these instabilities were investigated. At current densities and field strength values at which instabilities were observed, the effective Hall coefficient has been found to be nearly independent of the magnetic field strength. The measurements have shown that the efficiency of a noble-gas MHD generator is adversely affected not only by the decrease of the scalar conductivity in a magnetic field, which has been predicted by Feneberg, but also by the onset of instabilities. (auth)

3018 (IPPCZ-70) EFFECT OF MULTIPLE REFLECTIONS ON THE ACCURACY OF MICROWAVE-INTERFEROMETER MEASUREMENTS OF THE PLASMA-ELECTRON DENSITY. Musil, J.; Zacek, F. (Ceskoslovenska Akademie Ved, Prague. Ustav Fyziky Plazmatu). Dec. 1966. 10p. Dep.

An analysis is presented of the oscillatory character of the electron density variations as a function of the position of the receiving antenna relative to the axis of the plasma cylinder. The study deals with the following two cases: the plasma cylinder diameter D is far larger than the wave length, $D \gg \lambda$ and the diameter of plasma is comparable to the wave length $D \sim \lambda$. In the first case, the calculation starts from the plane slab approximation of the plasma, in the second from the scattering of the incident plane wave by the plasma. (auth)

3019 (JUL-480-PP) UNTERSUCHUNG DER IONISIERUNG VON WASSERSTOFF IN ELEKTRISCHEN RINGFELDERN MIT MIKROWELLENDIAGNOSTIK. (Investigation of the Ionization of Hydrogen in Electric Ring Fields With Microwave Diagnostics). Beerwald, H. (Kernforschungsanlage, Juelich (West Germany). Institut fuer Plasmaphysik). Apr. 1967. 49p. (In German). Dep.

The electron propagation occurring when a collision-dominated H_2 plasma of low ionization collides with a sufficiently strong electric field was measured. Microwave interferometry was used for the measurement of the electron density. The ionization of H_2 in electric ring fields is determined essentially by the electric field strength E, the gas pressure p, and the magnetic field B. If the magnetic field is small enough to be neglected, then the gas ionization can be described very simply with ionization degree. The reduced ionization degree is then a function of the quotient E/p. In gas discharge between electrons, space charge errors parallel to the imposed electric field occur with increasing electron density. This is in agreement with the theory of Rogowski and Fucks. At approximately 10^8 electrons/cc there occurs a significant decrease of the ignition voltage. Since in colloidal discharge no space charge errors occur in the current direction it is suitable for the measurement of the ionization degree at high electron densities. The measured values lie somewhat higher than the values previously known for very low electron densities. If the plasma column is axial in the homogeneous inducing magnetic field, then the ring field intensity increases linearly with the radius. The ionization occurs almost exclusively in the vicinity of the tube wall. Since with increasing frequency smaller magnetic field amplitudes induce sufficient electric field strength, at high frequency the effect of the magnetic field on the ionization can be neglected. In strongly oscillating magnetic fields the gas ionization was inhibited by the Lorentz power acting on the electrons. High electron losses occur through recombination at the tube wall. The electron density increases step wise in strongly oscillating magnetic fields. (tr-auth)

3020 LASER APPLICATION FOR THE PRODUCTION AND DIAGNOSTICS OF PULSED PLASMA. Basov, N. G.; Krokhin, O. N.; Sklizkov, G. V. (Lebedev Inst. of Physics, Moscow). Appl. Opt., 6: 1814-17(Nov. 1967).

A high-speed photography arrangement with a resolution power of 3 nsec is described which permits obtaining shadow and Schlieren photography and also interferometry. Such an arrangement was applied to the investigation of microplasma production by laser beam on the surface of a solid target. Shock wave velocities as high as 200 km/sec were registered and the electron density distribution in a plasma was defined. (auth)

3021 HIGH-TEMPERATURE MEASUREMENT. Kluge, K.; Kornyei, I.; Petkov, A. P.; Voros, T. (Univ. for Economic Sciences, Budapest. Univ. of Sofia. Univ. for Technical Sciences, Budapest). Acta Phys. Pol., 32: 399-403(1967).

A method is given for the determination of plasma temperature (T) from the quadratic Stark-effect shift ($\Delta\nu$) and broadening ($\Delta\gamma$) of spectrum lines. The application of the method is elaborated with the aid of an electronic computer for the elements Ni, Cu, Sr, Ba, and Pb, and diagrams show $\Delta\nu$ and $\Delta\gamma$ as functions of T. The diagrams make possible the determination of T after the measurement of $\Delta\nu$ or $\Delta\gamma$ of any spectrum line of the above elements. The method can be applied for the determination of plasma temperature in the region from 10^4 to 10^5°K in the case of thermodynamic equilibrium. (auth)

3022 ON THE INFLUENCE OF FLUCTUATIONS ON THE MEASUREMENT OF THE ELECTRON DISTRIBUTION FUNCTION IN PLASMAS BY LANGMUIR PROBES. Wiesemann, K. (Univ., Marburg, Ger.). Phys. Lett., 25A: 701-3(Nov. 6, 1967).

Measuring of second derivatives of probe characteristics in fluctuating plasmas produces cross modulations between the signal and the fluctuations. Expressions for the distortions by this effect are given and compared with the experiment. (auth)

3023 POSITIVE COLUMN IN APPROXIMATELY MAXWELL VELOCITY DISTRIBUTION OF ELECTRONS. Wojaczek, K. (Physikalisch-Technisches Institut, Berlin). Monatsber. Deut. Akad. Wiss. Berlin, 9: 156-60(1967). (In German).

The consideration of the deviations from the Maxwell velocity distribution of electrons permits a basic understanding of many phenomena of nonisothermal discharge columns. The column contraction, special similarity relations, and the existence of moving layers in the region of high-discharge current densities in rare gases belong to these phenomena. (tr-auth)

3024 DISTRIBUTION OF POTENTIAL AND CHARGED PARTICLE DENSITIES IN AN OSCILLATING ELECTRON DISCHARGE PLASMA. Brzhechko, L. V.; Pavlichenko, O. S. Zh. Tekh. Fiz., 37: 1508-13(Aug. 1967). (In Russian).

The potential and charged particle density distributions were calculated in a low-pressure cold cathode PIG discharge, taking into account the longitudinal potential drop in the vicinity of the cathode, and charge separation in the plasma. The equations of motion employed for the plasma electrons and ions comprise diffusion and mobility terms, and the source functions proposed

by Chen are used in the equations of continuity. These equations, together with Poisson's equation for the electric potential, are simplified with the aid of the following assumptions: the plasma is not highly ionized, so that the diffusion constants and mobilities are determined by collisions with neutrals; the plasma electrons are reflected from the cathode region according to an exponential law; all the ions reaching the cathode region are absorbed; the electron and ion temperatures, and consequently the transport constants, are independent of position; the Larmor radii of the plasma particles are small compared with the radius of the plasma; and the electrons remain sufficiently long between the cathodes to permit the beam electron multiplication factor to be approximated by the ratio of the electric potential to the ionization potential of the gas. The resulting equations were solved numerically for an argon plasma with the following parameter values: anode potential, 500 V; anode radius, 5 cm; cathode radius, 2 cm; cathode separation, 60 cm; magnetic field strength, 1 kOe; central plasma density, 10^{12} cm^{-3}; ion temperature, 0.3 ev; electron temperature, 20 eV; and argon pressure, 5×10^{-4} mm Hg. (ATD)

3025 INFLUENCE OF THE REFRACTION AND ABSORPTION OF THE MEDIUM ON THE COUPLING BETWEEN TWO ANTENNAS EMPLOYED IN PLASMA DIAGNOSTICS. Arsaev, I. E.; Kinber, B. E.; Ivanchinov-Marinskii, N. N. Zh. Tekh. Fiz., 37: 1495-1502(Aug. 1967). (In Russian).

The transmission factor was calculated for two horn antennas that face each other and between which there is an axially symmetric dielectric whose axis is perpendicular to and intersects the line joining the two antennas and whose complex scalar dielectric constant is an arbitrary function of the distance r from the axis. The calculations were undertaken because of their interest in connection with plasma diagnostics. The distortion due to refraction and absorption by the medium of the spherical wave emitted by the driven antenna is calculated by geometric optics methods, and the field induced in the receiving antenna by the distorted wave is calculated with a formula given by Kinber (Radiotekh. Elektron. 6: 907(1961)). By measuring the coupling between the antennas with different distances between them one can determine with the aid of the derived formula not only the integral of the dielectric constant across the dielectric (plasma) cylinder, but also two quantities that depend on the radial distribution of the dielectric constant. The polarization of the waves is not affected by the dielectric cylinder; any observed depolarization must therefore be ascribed to improper adjustment, lack of axial symmetry of the plasma, or the presence of a magnetic field. (ATD)

3026 INVESTIGATION OF A TURBULENT PLASMA BY MICROWAVE TECHNIQUES. Larionov, M. M.; Rozhdestvenskii, V. V.; Piliya, A. D. Zh. Tekh. Fiz., 37: 1471-6(Aug. 1967). (In Russian).

The attenuation and incoherent scattering of 4-mm-wavelength microwaves was used to investigate the turbulence of the discharge plasma in the "Al'fa" installation, which is stabilized by a weak magnetic field and the conducting wall of the toroidal discharge chamber. The investigation was undertaken because of the amplitude and phase fluctuations of transmitted microwave signals that were observed in earlier unsuccessful attempts to measure the plasma density by microwave interferometry during passage of the discharge current. For the attenuation measurements the transmitting and receiving horns were mounted opposite each other 90 cm apart. Although the critical plasma density for cutoff of 4-mm microwaves is 7×10^{13} cm^{-3}, the microwaves were attenuated by about 10 db when the plasma density was only 3×10^{13} cm^{-3}. It is concluded that microwave cutoff measurements of charged-particle densities in turbulent plasmas give erroneous results. The absorption coefficient for the microwaves was calculated from the effective electron collision frequency, which was determined from the low-frequency conductivity of the plasma; and the scattering coefficient, which was much greater than the absorption coefficient, was obtained by subtracting the absorption coefficient from the measured attenuation coefficient. From the scattering coefficients and the assumption that the mean diameter of the fluctuations responsible for the scattering was 2 cm, it was concluded that the mean square fluctuation of the refractive index of the turbulent plasma was about 1×10^{-5} at a plasma density of 1×10^{13} cm^{-3}, and 5×10^{-6} at a plasma density of 4×10^{13} cm^{-3}. For investigation of the incoherent scattering, the transmitting and receiving horns were so mounted that a signal could be received only as a result of multiple reflection of the microwaves from the conducting walls of the discharge chamber and multiple scattering in the plasma. The frequency spectrum of the scattered microwaves was analyzed with a superheterodyne receiver having a pass band of 4 MHz by frequency modulating the local oscillator to a 100-MHz swing. The scattered line was found to have an exponential shape and a width of some 30 MHz at 20 db down from the peak. From the scattered line shape and width it was calculated that the mean frequency shift in a single act of scattering was about 0.17 MHz for a plasma density of 1×10^{13} cm^{-3} and 0.9 MHz for a plasma density of 4×10^{13} cm^{-3}. These figures are in qualitative agreement with the frequencies of electric and magnetic field strength fluctuations measured with probes. It is concluded that some quantities characterizing the turbulence of a plasma can be derived from microwave scattering measurements, and it is pointed out that this diagnostic technique does not require contact with the plasma or disturbance of the plasma during the measurements. (ATD)

3027 MEASUREMENT OF THE EXTREME HIGH-FREQUENCY CONDUCTIVITY OF THE TURBULENT PLASMA IN THE AL'FA MACHINE. Larionov, M. M.; Rozhdestvenskii, V. V. Zh. Tekh. Fiz., 37: 1466-70(Aug. 1967). (In Russian).

The metal-walled toroidal discharge chamber of the Al'fa plasma machine was used as a microwave resonator to determine the conductivity of the plasma at microwave frequencies from the change in the Q of the chamber due to the presence of the plasma. The measurements were undertaken because of the large discrepancy between the theoretical and experimental values of the low-frequency conductivity of a turbulent plasma stabilized in a toroidal discharge by a weak longitudinal magnetic field. The chamber was excited (simultaneously in many modes) at about 75 kMHz with a horn antenna directed along a large radius of the torus. The level of the microwave field in the chamber was determined with the aid of a second horn antenna so mounted as to have no direct coupling to the exciting horn. In addition to the microwave Q measurements, the microwave power radiated by the plasma in the 4- and 8-mm-wavelength regions and the discharge current were measured, and the plasma concentration was determined with the aid of a probe beam of 10-keV neutral hydrogen atoms. During the measurements the hydrogen pressure in the chamber was $(4 \text{ to } 10) \times 10^{-4}$ mm Hg, the longitudinal magnetic field strength was 360 Oe, and the plasma temperature was 30 to 40 eV. The measured low- and high-frequency conductivities of the plasma were expressed as effective collision frequencies and are compared with the theoretical collision frequency calculated from the electron temperature and the ion density on the assumption of the Coulomb collision mechanism. The effective collision frequencies derived from both the high- and low-frequency conductivity measurements were found to be about an order of magnitude higher than the theoretical collision frequency. It is suggested that the discrepancy may be due to the presence of multiply charged impurity ions in the plasma and/or to wave absorption, scattering, and/or transformation processes associated with the turbulence of the plasma. (ATD)

3028 MEASUREMENT OF ELECTRON CONCENTRATION BY BROADENED HYDROGEN LINES. Dubrovskii, L. N.; Galushkin, Yu. I. Opt. Spectrosc. (USSR) (Engl. Transl.), 22: 478-84 (June 1967).

Translated from Opt. Spektrosk., 22: 876-88(June 1967).

The problem of quantitative verification of the theory of hydrogen-line broadening is solved and an attempt is made to apply the method of determining the electron concentration from the contours, as calculated in previous work, to the case when the line is radiated from an optically dense layer of plasma and allowance must be made for a strong continuum. (auth)

3029 A SPECTROSCOPIC METHOD FOR MEASURING THE CONCENTRATION DISTRIBUTION OF NEUTRAL ATOMS IN THE PLASMA FILAMENT IN THE TM-3 MACHINE. Kuznetsov, E. I. Zh. Tekh. Fiz., 37: 1550-3(Aug. 1967). (In Russian).

A mechanical scanning system was used to record the relative intensity distribution of the H_β line of atomic hydrogen along a diameter of the plasma filament in the TM-3 toroidal machine under the following experimental conditions: residual gas pressure before the discharge, 10^{-7} mm Hg; initial hydrogen pressure, 1.8×10^{-4} mm Hg; longitudinal magnetic field strength, 18 kOe; discharge current, 12 to 24 kA; duration of discharge, 6 millisec; scanning time, 300 μsec; diameter of plasma filament, 8 cm; electron temperature, 100 to 150 eV. The radial distribution of the relative concentration of excited hydrogen atoms was derived from the H_β intensity distribution on the assumption that the distribution is axially symmetric. The concentration of neutral hydrogen atoms had a relative minimum on the axis of the plasma filament. The radial distribution of hydrogen atoms is discussed qualitatively at some length in terms of the processes of decomposition, ionization, and charge exchange undergone by hydrogen molecules entering the plasma filament from

the outside. Energy is carried out of the plasma by fast neutral hydrogen atoms produced in charge exchange collisions of slow hydrogen atoms with fast hydrogen ions. The cooling effect of this process can be quantitatively evaluated on the basis of absolute intensity measurements of H_β and other atomic hydrogen lines. (ATD)

3030 PLASMA ELECTRON THERMALIZATION MEASUREMENTS UTILIZING THE SPECTRAL DISTRIBUTION OF LASER LIGHT SCATTERED BY PLASMA ELECTRONS. Bottoms, Paul Jean. College Station, Tex., Texas A and M Univ., 1966. 72p.

Thesis.

The Thompson-scattering method has been used to investigate the thermalization of plasma electrons in hydrogen, helium and argon plasmas. The thermalization measurements were made after the injection of the plasma into a semi-cusp magnetic field. The magnetic field was found to be effective in isolating the plasma while the thermalization measurements were made. The measurement of the temporal development of the plasma electron temperature yielded experimental results that were found to be in good agreement with the thermalization theory of Spitzer and Sivukhin. The results did, however, indicate a slower electron heating rate than is predicted by the theory. This effect is believed to have been caused by the loss of high-energy electrons during the thermalization process. (Disser. Abstr.)

3031 KINETIC THEORY SOLUTIONS FOR THE SPHERICAL ELECTROSTATIC PROBES IN A STATIONARY PLASMA. Chou, Yon Sun. Berkeley, Calif., Univ. of California, 1966. 97p.

Thesis.

The spherical electrostatic probe immersed in an infinite weakly ionized gas is studied from the kinetic theory point of view. The Boltzmann equations are transformed into an energy–angular momentum phase space. The charged particle motion is fully analyzed in this phase space. By using a Krook-type model for charged–neutral particle collision, a formal integral solution of the distribution function is discussed. Lees' moment equations are derived, and sample solutions for those moment equations are computed. From the sample solutions it is found that (a) The sheath effect is much more pronounced for a positive potential probe than a negative one. (b) On decreasing the ratio of Debye length to probe radius the ion current is decreased, the sheath effect is more pronounced, and the saturation ion current is reached at smaller negative probe potential. (c) The effect of collisions is to help the plasma to sustain more potential, to decrease both the ion current and electron current, as well as to reduce the excess ion number density in the sheath region. (d) In the collisionless case, when the ion temperature is increased the ion current is also increased. This increase becomes negligibly small at large negative probe potential. In the case with collisions, the ion current is increased for relatively small negative probe potentials, but is decreased at large negative probe potentials. Wasserstrom, Su, and Probstein's solutions (Phys. Fluids 8: 56, 1965) based on the straight-line trajectory approximation are compared with the results of this analysis. The agreement is found to be poor in general. (Disser. Abstr.)

3032 EFFECT OF INHOMOGENEOUS ELECTRON DENSITY AND COLLISION FREQUENCY IN A CYLINDRICAL PLASMA COLUMN SURROUNDED BY A HELIX. Kalagher, Richard James. Philadelphia, Univ. of Pennsylvania, 1966. 115p.

Thesis.

A system consisting of a cylindrical plasma column surrounded by a helix is studied. Particular attention is given to the effects that radial distributions of electron density and collision frequency have on the electromagnetic wave which propagates on the helix. The problem is solved by representing the plasma as a complex frequency dependent dielectric. Maxwell's equations are solved in the plasma region to obtain the electromagnetic field components. The boundary conditions on the helix are then applied to yield the dispersion equation. The dispersion equation is then solved, with the aid of a computer to obtain plots of phase shift vs. frequency and insertion loss vs. frequency for various values of the plasma parameters. Measurements were performed to verify the results of the theoretical analysis. It was found that the phase-shift curves for an inhomogeneous plasma were lower than those for a homogeneous plasma, but were qualitatively the same. The insertion loss showed a peak at a frequency equal to the plasma frequency. The magnitude of the peak was directly proportional to the collision frequency. By comparing a measured curve to the theoretical curves, therefore, the system can be used for plasma diagnostics. The results of the research have shown that plasma inhomogeneities do not qualitatively affect the wave on the helix. On the other hand, the plasma-helix system has proven useful as a plasma diagnostic tool. (Disser. Abstr.)

3033 TEMPERATURE MEASUREMENT AND INTERNAL FLOW HEAT TRANSFER ANALYSIS FOR PARTIALLY IONIZED ARGON. Incropera, Frank Paul. Stanford, Calif., Stanford Univ., 1966. 180p.

Thesis.

From a review of the arc-jet literature, three techniques are found to be best suited to the task of plasma-jet temperature measurement. Two of these techniques are spectroscopic and are referred to as the Larenz and two-line methods, and the third is calorimetric and operates by insertion of a probe in the plasma stream. An uncertainty analysis performed on each of the selected methods indicates that the most suitable spectroscopic technique is one which combines the ion–neutral, two-line method with the Larenz method. Spectroscopic and calorimetric probe measurements of temperature profiles in the same argon plasma source agree to within 4%, which is also the expected uncertainty predicted from the analysis. For all of the measurements made the values of the flow rate and enthalpy obtained from integration of local measurements over the jet cross section agree with the known flow rate and bulk enthalpy to within 10%. Criteria are proposed which may be used to select the diagnostic technique best suited to a particular application. (TSS) (Disser. Abstr.)

3034 SPECTROSCOPIC STUDY OF AN UNDER EXPANDED ARGON PLASMA JET. Bowen, Stuart Wayne. Ann Arbor, Mich., Univ. of Michigan, 1966. 358p.

Thesis.

Argon, heated to 5000°K at 7 atmospheres in a dc arc plasma generator, was expanded through a sonic orifice into the atmosphere, forming a self-luminous plume with the characteristic underexpanded jet structure. The 300-A arc was struck between a central tungsten cathode, seeded with Ba and Ca, and an outer, coaxial, water cooled copper anode. The arc was rotated at high speed by an external series field coil. The absolute intensity of the continuum radiation, as well as the absolute intensity of the line radiation from argon and the Ca and Ba and H impurity lines, was spectroscopically measured. The Stark-broadened profiles of the hydrogen Balmer series yielded the electron density. The various measurements allowed calculation of the absolute temperature, the Boltzmann temperature and the Saha temperature, which were compared to the kinetic temperature at various points in the jet. The radiation from the argon lines exceeded that predicted from local thermodynamic equilibrium and the static temperatures in the jet, obtained from the sonic orifice mass flow, by over 10 orders of magnitude at the nozzle exit, even though an equilibration time greater than 10^{-2} sec at chamber conditions was provided for the argon after arc passage. Selective, nonthermal excitation of the N_2 second positive band system was also observed, emanating from the mixing zone along the jet boundary. When a few percent H_2 was mixed with the argon, prior to arc passage, order of magnitude decreases in the intensity of the argon radiation were observed. The Balmer series intensity went through a maximum, while the continuum radiation and electron density decreased at an increasing rate at H_2 was added. The N_2 second positive radiation was quenched with less than 1% H_2 addition. Qualitatively similar results were obtained with N_2 addition to the argon, but no changes were found when a few percent He or Ne were added to the argon. (Disser. Abstr.)

3035 LIGHT SCATTERING IN PLASMA AS A DIAGNOSTIC AID. Kunze, H.-J. (Institut fuer Plasmaphysik, Garching, Ger.). 16p. (In German). (CONF-650459–1). DTIE.

From Conference on Physics of Plasma and Gas Discharge, Munich.

The theoretical principles on which light scattering in plasma can be used as a diagnostic aid are reviewed. The primary problems occurring in the use of light scattering are indicated. Three types of arrangements are considered: observation of the scattered light at small angles, at 90°, and at 180°. The sources of error in scattering studies are discussed. (J.S.R.)

3036 TEMPERATURE MEASUREMENT OF AN ALKALI METAL-SEEDED PLASMA IN AN ELECTRIC FIELD. Chu, Tsu-kai. Philadelphia, Univ. of Pennsylvania, 1966. 124p.

Thesis.

The gas temperature and the electron temperature of a potassium-and-sodium (NA–K alloy, 9 to 1 by weight) seeded plasma are measured. The carrier gas is argon at atmospheric pressure and is confined in a circular-cylinder geometry. Four seeding concentrations are reported here, with Na–K-to-argon ratio (by weight) α at 0.132%, 0.198%, 0.396% and 0.93%. The gas temperature is measured by a thermocouple with a shield to insulate it from the electric field which is applied to the gas. The electron temperature is determined by the measurement of radiation from the atomic transition of potassium. The input electric current den-

sity ranges from 0.35 to 12.5 amps/cm^2. Results of gas temperature measurements show that the gas temperature increases in the presence of an applied electric field. The radial distribution of gas temperature is nearly uniform, with deviation from uniformity beginning at about $r/r_b = 0.8$. A longitudinal gradient of gas temperature exists. In the direction of flow the gas temperature decreases at low input current but increases at high input current. The radial distribution of electron temperature is also found nearly uniform. For the two cases of low-seeding concentration, the measured electron temperature agrees with that calculated from an energy-balance equation when radiation loss is included in the calculation. For the two higher-concentration cases, the measured electron temperature is lower than the calculated value. The highest discrepancy is about 2% when the uncertainty of the value of transition probability is taken into account. Probes are inserted in the plasma to determine its electrical conductivity. The measured conductivity agrees with that reported by Kerrebrock and Hoffman, but is in general higher than that calculated from the measured electron temperature. The discrepancy increases as the seeding concentration increases. At $\alpha = 0.93\%$ and an electron temperature about 2700°K, the measured electrical conductivity is larger by a factor of 2. (Disser. Abstr.)

Kinetics of Plasma

3037 (AWRE-O-78/67) ELECTRICAL BREAKDOWN BETWEEN A PLASMA AND AN ELECTRODE AT A NEGATIVE POTENTIAL. Owen, W. D. (Atomic Weapons Research Establishment, Aldermaston (England)). Nov. 1967. 11p. Dep. CFSTI. UK 1s. 9d.

An analysis is made of the interaction between a plasma and an electrode at a negative potential. Expressions are derived for the electric field produced at the electrode surface as a result of the presence of the plasma and a possible mechanism of electrical breakdown based on field emission is considered. The parameters to be considered in the design of ion extracting electrode systems and the limits set on these in order to avoid field emission initiated electrical breakdown are outlined. (auth)

3038 (CEA-R-3278) ETUDE DE L'INJECTION DE PLASMA DANS UN CHAMP MAGNETIQUE A DOUBLE COURBURE. (Study of the Injection of Plasma into a Magnetic Field of Double Curvature Geometry). Lasry, Jacques (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). 1967. 110p. (In French). (EUR-3529f). Dep.

Thesis. Submitted to Paris Univ., Orsay, France.

A hydrogen plasma is injected along the lines of a magnetic field with a double-curvature geometry. The plasma is produced by a coaxial gun with an annular pre-ionization system. It is shown theoretically that the electric drift of the plasma can be cancelled if a depolarizing current flows along the field lines towards a region of good transverse conductivity. The experiment shows that in these conditions the curvature drift of the ions of the plasma may be used as a very efficient process to purify the fast component of the plasma. The depolarizing electron currents are measured and the mutual cancellation of the electric fields developing into the oppositely curved region is demonstrated to be possible. The current densities agree with the values deduced of the curvature drift of the ions. (auth)

3039 (CEA-R-3288) PUISSANCE DISSIPEE (OU GENEREE) PAR LES DIFFERENTS MODES EXCITES DAN UN PLASMA. (Power Dissipated (or Generated) by the Various Excited Modes in a Plasma). Rolland, Paul (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). July 1967. 53p. (In French). Dep.

The energy exchange between a plasma and a source of excitation $\sin w_0 t$ is investigated. In order to include the case of growing waves associated with convective instabilities, this problem is treated in the context of the wave-packet theory, by writing the field as a double integral in two complex planes. The paths of integration are defined after a separation into two classes of the roots $k(w)$ of the dispersion equation. It is found that, even in the absence of collisions, there still is a power exchange, due to the spatial dispersion. Thus a connection can be established with the kinematic theories of growing waves and the modes generating power can be found. Moreover, the power dissipated by spatial dispersion is found to be identical with that due to Landau's effect for long waves. This confirms the kinematic character of the latter and bridges a gap between macroscopic and microscopic theories. (auth)

3040 (IAE-1160, pp 15-28) KNUDSENOVSKII NIZKOVOL'TNYI RAZRYAD S GORYACHIM KATODOM. (Knudsen Low-Voltage Discharge with a Hot Cathode). Byrdin, Yu. A.; Lyubimov, B. Ya.; Nastoyashchii, A. F. (In Russian).

It was shown that in Knudsen discharge there are some electrons grouped according to energy. The electric discharge is transmitted by fast electrons of the beam. Slow electrons, formed as a result of ionization collisions, are indicated by trapped potential holes and form comparatively dense cold plasma with electron concentrations which can by many orders exceed the density of the electrons in the beam. On the basis of the examination there is a simple explanation of the resulting Langmuir paradox. Conclusions on the pattern of the volt–ampere characteristics and evaluation of the density of the cold plasma were confirmed by the experiments made. On the basis of the simple model of the turbulent plasma the mechanism of the ionization in the case of instabilities of the electron flux is discussed. The possibility of using discharges in inert gases for neutralization of 3-dimensional discharge in thermoemission converters is examined. (tr-auth)

3041 (IAE-1160, pp 29-42) K TEORII NIZKOVOL'TNOI DUGI V PARAKH Cs. (The Theory of Low-Voltage Arc in Cs Vapor). Nastoyashchii, A. F. (In Russian).

A theory of low-voltage arcs in short gas gaps is proposed. It is assumed that the ionization in the arc is maintained by the flux of fast electrons accelerated by the cathode barrier. The electrical current can be transmitted both by fast electron beam or by slow electrons. It is shown that the ionization state in the short arc must be characterized by some simple relations. The case of the low-voltage arc in Cs vapor is considered in detail. (tr-auth)

3042 (IPP-3/60) SELF-ABSORPTION RESONANCES AT THE ELECTRON-CYCLOTRON HARMONICS. Landauer, G. (Institut fuer Plasmaphysik, G.m.b.H., Garching (West Germany)). Sept. 1966. 17p. Dep.

Sharp self-absorption resonances at the electron-cyclotron harmonics ($n \approx 4$ to 18) appear in radiation spectra, when the PIG discharge is superimposed by a secondary plasma. This plasma is established by two electrodes which produce a static electric field $E \perp B$. The radiation level ("background"), in which at a frequency $f \approx 10$ GHz the self-absorption resonances could be observed, is rather high. On the contrary, normal cyclotron-harmonic emission spectra of the PIG discharge have low background radiation. (auth)

3043 (IPPCZ-64) EQUILIBRIUM CONFIGURATIONS OF PLASMA AND SELF-CONSISTENT FIELD WITH AXIAL SYMMETRY. [PART] II. Lacina, J. (Ceskoslovenska Akademie Ved, Prague. Ustav Fyziky Plazmatu). Mar. 1966. 37p. Dep.

The equilibrium configuration of plasma (the stationary distribution function of charged particles) and of the self-consistent magnetic field is determined on the basis of the first integrals of motion. A detail analysis is made of the mutual relation between the resultant magnetic field and the dependence of the distribution function on the integrals of motion; the necessary and sufficient conditions which must be satisfied by the distribution function with minimum-B are obtained. (auth)

3044 (IPPCZ-66) ON THE STATIONARY STATE OF A PLASMA IN MAGNETOSTATIC AND POTENTIAL FIELDS. PART II. Klima, R. (Ceskoslovenska Akademie Ved, Prague. Ustav Fyziky Plazmatu). June 1966. 18p. Dep.

The density distribution on the lines of force of the magnetostatic field is established under certain simplifying conditions for a plasma bounded by a combination of a magnetostatic and a potential field. The distribution functions of the particles, too, are determined for some of the cases being examined. It is found that certain nonlinear effects given by the action of the averaged high-frequency forces in the plasma can occur in experiments concerning the magnetoacoustic resonance of the plasma column. (auth)

3045 (IPPCZ-74) A NOTE ON THE PROPAGATION OF RIGHT-HAND AND LEFT-HAND CIRCULARLY POLARIZED WAVES IN A MAGNETOACTIVE PLASMA IN THE NEIGHBOURHOOD OF CYCLOTRON FREQUENCIES. Musil, J.; Teichmann, J. (Ceskoslovenska Akademie Ved, Prague. Ustav Fyziky Plazmatu). Jan. 1967. 11p. Dep.

Properties of propagation of plane right-hand and left-hand circularly polarized waves in an unbounded magnetoactive plasma in the neighborhood of electron and ion cyclotron frequencies are discussed. The regions of temperatures of the electron and ion components of the plasma and of the plasma densities in which the waves propagate either with a very weak attenuation $\kappa \ll n$ or with a very strong attenuation $\kappa \sim n$ are deduced from the dispersion equation derived in the linear approximation. It is demonstrated that a left-hand circularly polarized wave does not propagate in a plasma with density $N \geq 4 \times 10^{14} H^2/T_i$. (auth)

3046 (IPPJ-54) COMPUTER EXPERIMENTS WITH CHARGED PARTICLES, CHARGED FLUIDS, AND PLASMAS: A CLASSIFICATION AND BIBLIOGRAPHY. Birdsall, Charles K. (Nagoya Univ. (Japan). Inst. of Plasma Physics). Dec. 1966. 26p. Dep.

Computer experiments, performed with electron and ion superparticles and charged fluids, to simulate plasmas and streams, are listed by: (1) applications — 15 device areas and 15 unbounded plasma areas; (2) models — 11 superparticle models and one fluid model; and (3) publications — about 100 articles and reports over the past 10 years. It is concluded that this type of approach for many-body or nonlinear problems has now grown into valid partnership with analysis and laboratory experiments. (auth)

3047 (IPPJ-55) PLASMA COMPUTER EXPERIMENTS IN THREE DIMENSIONS: DEVELOPMENT OF A CODE FOR GUIDING CENTER FLUIDS. Birdsall, Charles K.; Kamimura, Tetsuo (Nagoya Univ. (Japan). Inst. of Plasma Physics). Dec. 1966. 49p. Dep.

An outline is given of a simple computer experiment code that can accept mirror plus Ioffe bar fields and follow the motion of a neutral or nearly neutral two-fluid plasma at low frequencies. The velocities of the two fluids are obtained by guiding center theory. Each fluid obeys an Eulerian equation of continuity; these equations are used to advance the densities each time step. (M.O.W.)

3048 (JUL-481-PP) ZUM IMPEDANZVERHALTEN DER STATIONAEREN HOCHFREQUENZRINGENTLADUNG. (Impedance Behavior of a Stationary High-Frequency Discharge). Geissler, E. (Kernforschungsanlage, Juelich (West Germany). Institut fuer Plasmaphysik). Apr. 1967. 7p. (In German). Dep.

For the suitable dimensioning of the high-frequency installation for the production of an inductively excited high-frequency plasma, the impedance of the plasma must be known as the quotient of the electrical field strength E and the magnetic strength H at the boundary of the discharge vessel. The relation between E and H was experimentally investigated. In periodically oscillating undamped magnetic fields (f = 7.2 MHZ and B ≦ 35) a stationary ring discharge in H_2 at 0.01 torr ≦ p ≦ 0.5 torr was produced. At significant skin effect, the relation $\hat{E} = A\hat{H} + B$, $\phi = C$ was found in a wide range of the inducing magnetic field. The constants A, B, and C used in the vessel dimensions depend only on the pressure. (tr-auth)

3049 (SIT-2813-42) GRAPHICAL COMPILATION OF CHARACTERISTIC QUANTITIES FOR CESIUM, POTASSIUM, AND BARIUM PLASMAS. Destler, William W. (Stevens Inst. of Tech., Hoboken, N. J. Dept. of Physics). Aug. 1967. Contract AT(30-1)-2813. 33p. (SIT-206). Dep. CFSTI.

Ion cyclotron frequencies, drift velocities, Larmor radii, electron-ion and ion-ion collision frequencies, Debye lengths, and plasma frequencies have been calculated for a wide range of temperatures, magnetic fields, and ion densities, and for the most part the graphs offer values for almost all reasonable parameters. Included also is a complete list of expressions and values used in the calculations. (M.O.W.)

3050 (SU-IPR-189) CYCLOTRON HARMONIC WAVE PHENOMENA IN PLASMAS. Crawford, F. W. (Stanford Univ., Calif. Inst. for Plasma Research). July 1967. Contract AT(04-3)-326. 30p. (CONF-670810-5). Dep. CFSTI.

From 8th International Conference on Phenomena in Ionized Gases, Vienna, Austria.

A review is presented of the correspondence between the theoretical and experimental activities in the field. The most significant result of the work is that, since the CHW propagation is predicted only by microscopic theory based on the Boltzmann equation, the close agreement between theory and experiment adds considerably to our confidence in the mathematical procedures governing the description of warm magnetoplasma wave and instability properties. The results complement those on Landau damping obtained under conditions where magnetic field effects are unimportant. (M.O.W.)

3051 ANISOTROPIC PROPAGATION AND DAMPING OF ION-ACOUSTIC WAVES IN A CURRENT-CARRYING PLASMA. Sato, Noriyoshi; Sasaki, Akihiko; Aoki, Kazuyuki; Hatta, Yoshisuke (Tohoku Univ., Sendai). Phys. Rev. Lett., 19: 1174-6 (Nov. 13, 1967).

Experimental results and qualitative discussions are presented on anisotropic propagation and damping of ion acoustic waves due to an electric current in a hot-cathode mercury discharge of several hundred milliamperes. (M.O.W.)

3052 SHAPE OF THE BOUNDARY OF A FREELY SPREADING PLASMA IN A MAGNETIC FIELD. Pilipenko, V. A. Zh. Prikl. Mekh. Tekh. Fiz., No. 2, 126(Mar.-Apr. 1967). (In Russian).

This is a continuation of work by Yu. P. Raizer (Zh. Prikl. Mekh. Tekh. Fiz., No. 2 (1966)) who considered a number of physical processes occurring when a plasma expands in a vacuum containing a magnetic field, under the assumption that the boundary between the plasma and the magnetic field is spherical. The purpose of the present article is to take into account nonsphericity of the plasma-cloud boundary. The author estimates the shape of the plasma-cloud boundary at the instant of its deceleration from the condition that the free flow of a plasma, which crowds out a magnetic field completely as it expands from a point, is equal to the pressure of the external magnetic field. The resultant equation is solved numerically and a diagram showing the asymptotic shape of the plasma boundary is presented. (ATD)

3053 METHOD FOR SOLVING THE KORTEWEG-deVRIES EQUATION. Gardner, Clifford S.; Greene, John M.; Kruskal, Martin D.; Miura, Robert M. (Princeton Univ., N. J.). Contract AF49(638)-1555. Phys. Rev. Lett., 19: 1095-7(Nov. 6, 1967).

A method for solving the initial-value problem of the Korteweg-deVries equation is presented which is applicable to initial data that approach a constant sufficiently rapidly as $|x| \to \infty$. The method can be used to predict exactly the "solitons," or solitary waves, which emerge from arbitrary initial conditions. Solutions that describe any finite number of solitons in interaction can be expressed in closed form. (auth)

3054 EMISSIVITY AND RELATION BETWEEN THE TEMPERATURE OF ELECTRONS AND IONS OF AN OPTICALLY TRANSPARENT PLASMA. Kuznetsov, N. M. Zh. Prikl. Mekh. Tekh. Fiz., No. 2, 141-4(Mar.-Apr. 1967). (In Russian).

The purpose of the investigation was to examine quantitatively the conditions under which the electron temperature (T) is not equal to the ion temperature (T_i) even though the electronic states are in local thermodynamic equilibrium. To this end, a more exact expression is obtained for the absorption coefficient of a hydrogen plasma; this expression goes over into the standard formula for free-free absorption in the limit when the ionization is complete. The emissivity of a high temperature spatially homogeneous gas is investigated and a connection is obtained between the T and T_i in a plasma which is in local thermodynamic equilibrium and is transparent for free-bound and free-free radiation. It is shown that the discrepancy between the electron and ion temperatures is due to radiation losses of plasma energy and that considerable deviation from the unity temperature ratio at a specified constant ion temperature sets in the case of air and heavier gases at $T > 10^{5}$°K. In the case of a plasma which is cooled by radiation, the deviation of T/T_i from unity at the same values of T is smaller by approximately one order of magnitude than in the stationary case. Numerical values are obtained for the case of an air plasma of normal density. (ATD)

3055 MOTION OF A CHARGED GAS FILLING A CYLINDRICAL CAVITY WITH A CROSS SECTION IN THE FORM OF AN ARBITRARY ELLIPSE. Levin, V. A. Zh. Prikl. Mekh. Tekh. Fiz., No. 2, 122-5(Mar.-Apr. 1967). (In Russian).

The motion considered is that of a single-component charged gas, in an external magnetic field and without a field, filling the cavity at the initial instant of time. The constant magnetic field is applied along the cylinder axis, and the induced magnetic field is neglected. The gas motion is essentially two-dimensional. Although a solution could not be obtained for the general case, it can be obtained for the case of homogeneous relative deformation of the gas. It is shown that since the cross section of the cavity is initially elliptical, the potential is quadratic, leaving the dependence of the velocity on the coordinates linear in time. The density is therefore homogeneous at each instant of time over the entire cross section, which remains elliptical, but the dimensions of the ellipse and its orientation in space vary with time. The results can be used to describe the behavior of ribbon-shaped beams of charged particles with elliptic cross section, where it can be shown that such beams have aperiodic structure with principal axes rotating along the beam. (ATD)

3056 STATIONARY SOLUTIONS OF THE QUASILINEAR APPROXIMATION EQUATIONS IN A PLASMA WITH COLLISIONS. Klimontovich, Yu. L.; Logvinov, V. V. Zh. Prikl. Mekh. Tekh. Fiz., No. 2, 35-40(Mar.-Apr. 1967). (In Russian).

The equations for quasi-linear approximation for a plasma with collisions were derived in a book by one of the authors (Klimontovich, Statistical theory of nonequilibrium processes in plasma, Izdatel' stno Nauka, Moscow, 1966), where the equations were derived for a monochromatic longitudinal wave. In the present paper the theory is extended to oscillations with larger amplitudes. Expressions are derived from the momentum and energy balance equations for the drift velocity of the electrons and for the electron and ion temperature difference in a two-component plasma in a specified wave field, under the assumption that the background distribution function of the electrons and ions can be regarded as Maxwellian. This is followed by an analysis of the steady-state

high frequency Langmuir waves that are produced when a constant electron beam is present in the plasma, and the amplitude of these waves is determined. The electron stationary distribution function is then calculated in the one-dimensional case, using a model collision integral, and is found to differ little from Maxwellian in the case of weak spatial dispersion. (ATD)

3057 ON THE ROLE OF DECAYS OF LANGMUIR WAVES INTO ION-ACOUSTIC WAVES WHEN AN ELECTRON BEAM INTERACTS WITH A NONISOTHERMAL PLASMA. Liperovskii, V. A. Zh. Prikl. Mekh. Tekh. Fiz., No. 2, 23-30(Mar.-Apr. 1967). (In Russian).

Earlier (Zh. Prikl. Mekh. Tekh. Fiz., No. 2 (1966)) Tsytovich dealt with the conditions under which a Langmuir wave breaks up into another Langmuir wave and an ion sound wave. It is shown here, by solving the quasi-stationary system of differential equations for the plasma-plus-beam system, that such a decay is capable of stabilizing the system and reducing the interaction between the beam and the plasma. Depending on the injection conditions and on the number of reflections of the sound waves from the walls of the system, one or several quasi-stationary states can be produced. If the sound waves resonate with the decays, Langmuir waves generated by the beam may become interacting. Numerical estimates are made for the case of a hydrogen plasma. (ATD)

3058 THEORY OF FOUR-PLASMON PARAMETRIC EXCITATION AND COMPARISON WITH EXPERIMENT. DuBois, D. F. (Hughes Research Labs., Malibu, Calif.); Goldman, M. V. Phys. Rev. Lett., 19: 1105-10(Nov. 6, 1967).

The results of the theory of four-mode parametric excitation in an infinite, homogeneous, collisionless plasma are presented. Based on the extrapolation of these results to the experimental plasma of Stern and Tzoor (Phys. Rev. Lett. 17: 903(1966)) and assuming that their measured and computed linear system parameters such as lifetimes, pump power, etc., are correct, it is concluded that it is possible that an effect other than parametric excitation is responsible for their observations. (M.H.R.)

3059 RADIATION FROM AN ELECTRIC DIPOLE IN AN AXIALLY MAGNETIZED PLASMA COLUMN: DIPOLAR MODES. Yip, G. L. (Univ. of Toronto); Seshadri, S. R. Can. J. Phys., 45: 3627-48(Nov. 1967).

The radiation characteristics of an electric dipole are investigated for the case in which it is situated on, and oriented perpendicular to, the axis of an infinitely long and axially magnetized column of uniform, lossless, and cold plasma. In general, the electric dipole will excite space waves as well as guided waves, both of which are dipolar in nature. The radiation power pattern and the radiation resistance, resulting from the space waves, are investigated as a function of the column radius, the signal frequency, and the strength of magnetization. For thin and isotropic plasma columns, the radiation resistance has a maximum, which is due to the dipolar resonance. This resonance occurs at $1/\sqrt{2}$ times the plasma frequency. The introduction of anisotropy by the application of an axial magnetic field results in the splitting of the single dipolar resonance into two, occurring at frequencies below and above $1/\sqrt{2}$ times the plasma frequency. Finally, a comparison is made between the radiation characteristics in the present problem and those due to an axially oriented dipole. (auth)

3060 NONLINEAR EFFECTS IN THE DIPOLE RESONANCE OF A PLASMA COLUMN AT HIGHER RF POWERS. Gregory, B. C. (Trent Univ., Peterborough, Ont.); Mourier, G. Can. J. Phys., 45: 3649-62(Nov. 1967).

The increase of electron temperature as a function of the incident rf power of a cylindrical plasma column in a waveguide at the dipole resonance is studied. Measured values are consistent with the view that the electron temperature is limited by inelastic collisions. Section III of the paper uses an equivalent circuit model of the plasma column to explain theoretically the observed deformation of the dipole resonance curve with increasing incident rf power. All features of the experimentally observed deformation are successfully explained. (auth)

3061 CAUSE OF THE DARK-SHEATH IN RF PLASMOIDAL DISCHARGES. Kregel, M. D.; Miller, A. (New Mexico State Univ., Las Cruces). Appl. Phys. Lett., 11: 316-18(Nov. 15, 1967).

The "dark-sheath" region in plasmoidal discharges is known to be a high field region, and measurements of the relative emission rates from molecular oxygen ions and neutral oxygen atoms show that only the intensity of the molecular ion lines drop sharply in the "dark sheath." It is proposed that the dark-sheath region occurs because the lifetimes of the excited states of the molecular ions are long enough to permit an appreciable fraction of newly created ions to be swept away by the static electric field prior to radiative de-excitation. (auth)

3062 MAGNETIC LENS ANALYSIS OF FAST ELECTRONS IN THE NEGATIVE GLOW. Woolsey, G. A.; Reynolds, R. M.; Clarke, L. P. (Queen's Univ., Belfast). Phys. Lett., 25A: 656-8(Nov. 6, 1967).

The short magnetic lens technique used in beta-ray spectroscopy is applied to the fast electrons entering the negative glow from the cathode dark space in a helium glow discharge. Information can be obtained about the decrease of electron energy and number density through the negative glow. The method also gives information about the range of the fast electrons. (auth)

3063 ELECTRON ENERGY DISTRIBUTIONS IN MOVING STRIATIONS. Rayment, S. W.; Twiddy, N. D. (Univ. of York, Eng.). Nature (London), 216: 674-6(Nov. 18, 1967).

Pekarek's theory of the wave of stratification has been extended to cover self-excited moving striations (J. Appl. Phys. 37: 377 (1966)). This theory, which assumes a Maxwellian energy distribution, implies that an essential characteristic of moving striations is a phase shift between the maxima in the variation of the electron density and electron temperature. The theory is, however, linear, whereas the large amplitude and nonsinusoidal shape of the observed variations imply a nonlinear wave. Comparison with the familiar stationary striations, often found in molecular gases, would indicate the existence of a double-peaked electron energy distribution. The concept of electron temperature is then inadequate, particularly in view of the fact that the departure from Maxwellian form is greatest in the high energy tail of the distribution, which determines the production rate of ions and metastables. For this reason the electron energy distribution in moving striations was obtained using the Druyvesteyn probe technique (Proc. Roy. Soc. Lond. A, 259: 145 (1960)), time-resolved first derivative measurements being made and the second derivative being obtained by graphical differentiation. Measurements were made in a hot cathode discharge in neon, in which two types of moving striations were observed. The observed variations of light intensity with time are shown graphically, together with energy distribution measurements made in the higher current striations. Results show the two well-defined groups of electrons characteristic of stationary striations. Some measurements made in the striations occurring at lower currents are also depicted. Results are discussed. (UK)

3064 STOCHASTIC HEATING EXPERIMENT. Puri, S.; Dunn, D. A.; Thomassen, K. I. (Stanford Univ., Calif.). Phys. Lett., 25A: 694-5(Nov. 6, 1967).

A collisionless plasma in a magnetic mirror is heated by an externally applied random electric field acting transverse to the magnetic field direction. The electron heating rate is found to be $1.0 \times 10^5 E^2$ eV/sec, in good agreement (within a factor of two) with the value predicted by a theoretical analysis. (auth)

3065 LANDAU NONLINEAR DAMPING OF A PSEUDO-SOUND IONIC WAVE. Doucet, H.; Gresillon, D. (Ecole Polytechnique, Paris). Phys. Lett., 25A: 697-8(Nov. 6, 1967). (In French).

A nonlinear damping of ion-acoustic waves is observed in a cesium plasma. (auth)

3066 COLLECTIVE DESCRIPTION OF ELECTRONS IN THE GENERALIZED RPA. Sips, V. (Inst. Rudjer Boskovic, Zagreb). Phys. Lett., 25A: 698-9(Nov. 6, 1967).

The collective description of an electron gas is formulated in the approximation which takes into account the diagonal exchange terms. Special attention is paid to the influence of exchange and correlation effects on the plasmon frequency. (auth)

3067 RADIATION OF SHF NOISE OSCILLATIONS OF ANOMALOUS INTENSITY BY GAS DISCHARGE PLASMA. Kazanskaya, A. Ya.; Yastrebov, A. B. Radiotekh. Elektron., 12: 738-9(Apr. 1967). (In Russian).

Some of the noise-generating properties of hot cathode-arc discharges in plasma under low pressure are described. The noise was observed in the saturation portion of the volt-ampere characteristics of the discharge, i.e., under balanced space-charge conditions around the cathode. The discharge generators used in the experiments were cylindrical coaxial diodes with directly heated cathodes. The generators had pin outputs that could be coupled either to coaxial lines or to waveguides. Gas discharge took place in mercury vapor under pressures of .003 to .02 mm Hg. Operation of the diode tubes was continuous at anode voltages of 30 to 60 V and discharge currents of 30 to 200 mA. The outstanding property of the gas discharge was the existence of oscillations with a noise spectrum, a high noise temperature, and a significant bandwidth. (ATD)

3068 INTERACTION OF AN ELECTRON BEAM WITH A TRANSVERSE NONUNIFORM PLASMA LAYER. Karplyuk, K. S.; Levitskii, S. M. (Kiev State Univ.). Radiotekh. Elektron., 12: 655-8(Apr. 1967). (In Russian).

Propagation of electromagnetic waves in limited conducting planes of a plasma waveguide penetrated by an electron beam was studied in the case of trapezoidal plasma density distribution along the waveguide. Additional amplification or damping of waves when the virtual part of transverse dielectric penetrability of the plasma–beam system reversed to zero inside the plasma waveguide is discussed. (tr-auth)

3069 DEFLECTION OF CHARGED PARTICLES BY A CURRENT-CARRYING PLASMAJoyce, Glenn; Montgomery, David; Roque, Celso (Univ. of Iowa, Iowa City). Phys. Fluids, 10: 2399-2404(Nov. 1967).

Previously derived formal expressions for the mean-square deflection of a beam of energetic test particles from a spatially uniform plasma are evaluated numerically. The plasma electrons are assumed to be drifting relative to the ions with a velocity which ranges between zero and the critical drift velocity for the onset of the ion sound wave instability. Though the scattering angle diverges at the stability boundary, one must be able to make the drift velocity prohibitively close to the critical drift velocity (to within a small fraction of a percent of it) to see a marked enhancement. In no case was the scattering enhanced over the thermal value by as much as a factor of 10. (auth)

3070 ANGULAR SPECTRUM OF ION CYCLOTRON HARMONICS. Furutani, Y. (Univ. of Paris, Orsay, France); Kalman, G. Phys. Fluids, 10: 2405-8(Nov. 1967).

The combined effect of the anisotropic and frequency-dependent character of the polarizability of a magnetoplasma which gives rise to a very peculiar and energy-dependent angular distribution of the radiation emitted by a test ion, is considered. (auth)

3071 COLLISIONLESS ABSORPTION AND EMISSION OF ELECTROMAGNETIC WAVES BY A BOUNDED PLASMA. Hinton, F. L. (California Inst. of Tech., Pasadena). Phys. Fluids, 10: 2408-16(Nov. 1967).

The absorption and emission properties of a hot bounded plasma can be greatly influenced by collective behavior in the plasma. A homogeneous slab model of a collisionless plasma is used in a theoretical study of these collective effects. Peaks in the absorptivity occur at the resonance frequencies of longitudinal standing waves in the plasma. Power can be absorbed from an incident electromagnetic wave by Landau damping of the plasma waves which it couples to. Radiation is emitted from a collisionless bounded plasma because plasma waves excited in the wakes of fast electrons are partially converted to electromagnetic waves at the plasma boundaries. The radiation has peaks at the same frequencies as the absorption because of the collective reinforcement of the plasma waves at their resonance frequencies. In thermal equilibrium the collisionless absorption and emission obey Kirchhoff's law. The emission may be enhanced if many nonthermal electrons are present. (auth)

3072 NONLINEAR PLASMA WAVES. III. NONLINEAR TEMPERATURE EFFECTS IN THE ELECTRON–ION TWO-STREAM INSTABILITY. Freidberg, Jeffrey P. (Polytechnic Inst. of Brooklyn, Farmingdale, N Y.). Phys. Fluids, 10: 2417-26(Nov. 1967).

The nonlinear interaction of two warm interpenetrating electron and ion streams is treated by investigating the traveling wave solutions to the two fluid macroscopic plasma equations. These equations are reduced to the form of a nonlinear differential equation with an additional small nonlinear term. Application of the perturbation procedure, described previously (Freidberg, Phys. Fluids, 10: 171(1967)), leads to (1) conditions on the maximum amplitudes for which traveling-wave solutions exist and (2) a nonlinear amplitude-dependent dispersion relation. An examination of this dispersion relation indicates that below a certain critical temperature there is a range of wave numbers where the two stream instability may level off before the amplitude reaches the maximum amplitude for existence of traveling-wave solutions. This range of wave numbers decreases with increasing temperature and, therefore, is largest when the temperature is zero. (auth)

3073 STOCHASTIC ELECTRON HEATING AND HYDROMAGNETIC WAVE DAMPING. Barnes, Aaron (Ames Research Center, Moffett Field, Calif.). Phys. Fluids, 10: 2427-36(Nov. 1967).

Physical processes involved in collisionless damping of the fast hydromagnetic mode are investigated by considering the stochastic heating of electrons by a random spectrum of fast waves. We take as a model a weakly damped fast wave, propagating in a direction such that the damping is mainly due to electron heating; allowance is made for the possibility of a small component of electric field parallel to the unperturbed field. To estimate the damping we consider an ensemble of electrons accelerated (1) by magnetic-moment magnetic-field-gradient interaction and (2) by the parallel electric field. Electron heating is calculated from a Fokker–Planck type of equation; the damping decrement is obtained by equating the electron heating rate to the wave energy loss rate, and agrees with the damping decrement obtained from the appropriate asymptotic limit of the general dispersion relation. Some general aspects of this method for obtaining wave-damping decrements are discussed. (auth)

3074 THEORY OF RAREFACTION WAVES IN PLASMAS BEARING LARGE CURRENTS. Paxton, G. W. (Univ. of Oklahoma, Norman). Phys. Fluids, 10: 2360-74(Nov. 1967).

A plasma bearing a large current is shown to permit three classes of expansions in the direction of the current path: (1) normal rarefaction, (2) discontinuous or shock rarefaction, (3) extension or waveless rarefaction. The general problems are analyzed and application is made to a hydrogen plasma. (auth)

3075 THEORY OF THE LOW-PRESSURE POSITIVE COLUMN IN A TRANSVERSE MAGNETIC FIELD. Anicin, B. A. (Boris Kidrich Inst. of Nuclear Sciences, Belgrade). Phys. Fluids, 10: 2377-83(Nov. 1967).

When a positive column is submitted to a transverse magnetic field the Lorentz force compresses the electron gas towards one side of the vessel containing the plasma. This phenomenon is analyzed in planar geometry at low gas pressure. The ion mean free path is assumed to be at least several times the discharge width. The behavior of the ionic gas is treated using a fluid type version of free fall theory. Plasma density and potential profiles are obtained for various magnetic field strengths. The potential difference between the two insulating discharge walls, or the Hall voltage, is derived and found to be a nonlinear function of the magnetic field. The solution of the free-fall problem permits to formulate the five equations of balance of a magnetized plasma slab. These are used to determine the electron temperature and the longitudinal electric field of the positive column. (auth)

3076 IONIZED LAMINAR BOUNDARY LAYER EQUATIONS. Tabaczynski, R. J.; Goldstein, M. E. (Massachusetts Inst. of Tech., Cambridge). Phys. Fluids, 10: 2500-2(Nov. 1967).

The results of previous work on the multicomponent laminar boundary layer problem are extended to include two temperature ionized gases and calculations are performed for the equilibrium thermal conductivity of partially ionized argon. (auth)

3077 PLASMA OSCILLATIONS IN AN EXTERNAL ELECTRIC FIELD. Gorman, D. (McDonnell Douglas Corp., St. Louis). Phys. Fluids, 10: 2502-4(Nov. 1967).

A diffusely reflecting wall bounding an electron plasma modifies the law of penetration of longitudinal waves excited by an external field from that found by Landau for the case of specular reflection. (auth)

3078 ANISOTROPIC COMPRESSION OF A RELATIVISTIC PLASMA. Noerdlinger, Peter D.; Yui, Alexander Ko-Min (Univ. of Iowa, Iowa City). Phys. Fluids, 10: 2505(Nov. 1967).

The momentum distribution is calculated for a relativistic plasma originally in thermal equilibrium which has been subjected to a slow anisotropic compression. (auth)

3079 CORRELATION OF ROTATING VANE FREQUENCY WITH ANODE DIAMETER IN A REFLEX DISCHARGE. Dunnill, W. A. (ARO, Inc., Tullahoma, Tenn.); Shipp, J. I.; Flowers, J. W. Phys. Fluids, 10: 2506-7(Nov. 1967).

The rotation frequency of a vane of plasma in a hollow cathode reflex discharge has been shown to be a function of the effective inner radius of a ring-type anode. (auth)

3080 NONCORRELATION OF ANOMALOUS PLASMA TRANSPORT, EQUILIBRIUM PLASMA DENSITY, AND LOW-FREQUENCY POTENTIAL OSCILLATIONS IN A Q-DEVICE. Decker, John A. Jr.; Freyheit, P. J.; McBee, W. D.; Shepherd, L. T. (Sperry Rand Research Center, Sudbury, Mass.). Phys. Fluids, 10: 2442-54(Nov. 1967).

The minimum-B magnetic field, provided by the superposition of a transverse quadrupole-cusp field and a uniform axial field, suppressed certain of the low-frequency oscillations spontaneously present in the thermal cesium plasma of the TOPSY Q device with the uniform axial field alone, in conjunction with a sharp increase in the center-line equilibrium plasma density of up to two orders of magnitude. However, measurements of the transverse plasma flux immediately prior to and immediately after oscillation suppression failed to detect any change in the radial plasma transport; the "anomalous diffusion" observed in the TOPSY plasma in a uniform magnetic field is still present in the absence of low-frequency potential oscillations. Rather than being a function of plasma-column oscillations, the observed cross-field plasma transport is quantitatively explained in terms of E/B drifts due to azimuthal ionizer-plate temperature gradients. The sharp density increase

which accompanied oscillation suppression must thus be ascribed to changes in the ionizer sheath conditions leading to an increased "source" flux of plasma into the column from the ionizer, rather than to a decrease in the radial plasma "loss" flux. These results have serious implications for the study of transport processes in plasmas and, in particular, call into question the use of Q devices for the experimental study of "anomalous diffusion" in complex magnetic field geometries. (auth)

3081 ONE-DIMENSIONAL STATIC PINCH SOLUTIONS. Lam, S. H. (Princeton Univ., N. J.). Phys. Fluids, 10: 2454-7(Nov. 1967).

Exact (quasi-neutral) one-dimensional static pinch solutions are obtained when the distributions functions are allowed to have two perpendicular temperatures. The solutions can simulate plasma-magnetic field interfaces, single sheet pinches, and periodic pinches. (auth)

3082 COHERENT AMPLIFICATION BY AN ELECTRON STREAM OF THE QUASI-STATIC OSCILLATIONS OF A BOUNDED MAGNETOACTIVE PLASMA. Shishkin, L. A. (Physical-Technical Inst. of Low Temperatures, Kharkov). Zh. Tekh. Fiz., 37: 1503-7(Aug. 1967). (In Russian).

The excitation of oscillations in a plasma occupying the region $r < R$, $\Theta < z < L$ (r, Θ, and z are cylindrical coordinates) by an electron stream occupying the region $r > R$ is discussed. The calculations were undertaken because of their possible electronic applications. It is assumed that in the unperturbed state the electron density is constant in the region $r > R$, that the electron in this region (i.e., in the electron stream) all have the same velocity v in the z direction, and that there is a uniform magnetic field, also in the z direction. The plasma is described by its dielectric tensor, whose components depend in the usual way on the field, Larmor, and Langmuir frequencies. Maxwell's equations and the equation of motion for the electrons outside the plasma are linearized for small perturbations that are independent of Θ and proportional to $\exp(i\beta z - ift)$, where t is the time, f is the (radian) field frequency, and β is a parameter. From the boundary condition at $r = R$ on the solution to the linearized equations there is derived a dispersion equation, the roots of which are discussed for small values of R. Resonance growth of the oscillations takes place with maximum growth rates at frequencies of βv and $\beta v - F$, where F is the Larmor frequency of the plasma and $\beta = \pi n/L$, where n is an integer. The growth rate of the βv oscillation is proportional to $q^{\frac{1}{3}}$, and that of the $\beta v - F$ oscillation, to $q^{\frac{1}{2}}$, where q is the charge density in the electron stream. (ATD)

3083 SPACE CHARGE EFFECTS IN HIGH-FREQUENCY GAS DISCHARGES. Anashkin, G. A. (Moscow Evening Metallurgical Inst.). Zh. Tekh. Fiz., 37: 1481-7(Aug. 1967). (In Russian).

The electrical breakdown of air and argon was investigated between 0.3- and 1.0-cm-diameter coaxial electrodes (these being the dimensions of a standard 75-ohm coaxial waveguide) at frequencies in the 18- to 85-cm-wavelength range. The measurements were undertaken to explore the frequency range in which the diffusion theory of high-frequency breakdown of S. C. Brown and collaborators (Phys. Rev., 74: 291, 910 and 1650(1948); 75: 411 and 1324(1949); 76: 1629 and 1634(1949)) is valid. The waveguide section containing the investigated gas was closed with walls that were transparent to the microwaves. Standing waves were generated with a voltage loop in the discharge section, and the power level was increased until discharge took place. The power level was measured at a second standing wave loop. The results are presented as curves showing the electric field strength at breakdown as a function of gas pressure for the different gases and different frequencies. A few curves are also presented showing the breakdown field for argon as a function of frequency. Considerable deviations between the experimental results and the predictions of the diffusion theory were found. These deviations, which were not all in the same direction, are discussed at some length; they are ascribed to space charge effects arising from differential motion of the electrons and ions in the high-frequency field. The breakdown field of argon was found to increase particularly rapidly with increasing frequency in a narrow frequency range around 600 MHz, and a similar behavior has been observed in uniform field discharges, but at a much lower frequency (about 200 MHz). This behavior is also ascribed to space charge effects. (ATD)

3084 EXCITATION OF IONIC SOUND INSTABILITY IN A NONUNIFORM PLASMA. Buchel'nikova, N. S.; Salimov, R. A.; Eidel'man, Yu. I. Zh. Tekh. Fiz., 37: 1477-80(Aug. 1967). (In Russian).

The ionic sound and drift instabilities were investigated of a strongly ionized plasma produced by thermal ionization of potassium on a 4 cm diameter tungsten plate (ionizer) heated to 2000°K, and held in the 36 cm gap between the ionizer and a second unheated electrode by a 400 to 2000 Oe longitudinal magnetic field. The plasma density was 10^9 to 10^{10} cm^{-3}, and the residual gas pressure was $(2 \text{ to } 8) \times 10^{-7}$ mm Hg. The plasma behavior was studied as a function of the electron drift velocity, defined as the ratio of the current density to the electron density in the plasma. The plasma density and the amplitude of the oscillations were determined from the dc and ac components of the saturation current to a Langmuir probe. The plasma behaved differently, depending on whether there was formed an ion layer (case I) or an electron layer (case II) on the ionizer. The case I experiments have been described in more detail elsewhere by the authors (Yadern. sintez, 6: No. 4, 1966). In this case drift instability was present and the amplitude of the ion sound oscillations increased continuously from zero when the electron drift velocity was increased beyond a certain critical value and decreased continuously to zero when the drift velocity was again brought down to the same critical value. In case II, when there was no drift instability, the ionic sound amplitude increased discontinuously from zero to a finite value when the increasing electron drift velocity reached a certain critical onset value and dropped again to zero only when the decreasing drift velocity reached a second, lower, critical value. According to the theory of Vedenov (Usp. Fiz. Nauk, 84: 533(1964)), the ratio of the onset discontinuity to the terminal discontinuity in the amplitude of the ionic sound oscillations should be $2\frac{1}{2}$; the ratio was found experimentally to be 1.6 ± 0.3. (ATD)

3085 ON CALCULATION OF THE ELECTRON DISTRIBUTION FUNCTION IN A LOW-TEMPERATURE MOLECULAR GAS DISCHARGE PLASMA. Soshnikov, V. N.; Trekhov, E. S. (Moscow Engineering Physics Inst.). Zh. Tekh. Fiz., 37: 1414-21(Aug. 1967). (In Russian).

The kinetic equation for the electron distribution function in a low-temperature molecular gas discharge plasma was expressed in an integral form suitable for solution by an iteration procedure. The kinetic equation includes the effects of the electric field, of electron–electron collisions, and of both elastic and inelastic electron–molecule collisions, and it can accommodate arbitrary energy dependence of the different electron–molecule collision cross sections. The investigation was undertaken because of the appearance of the data of Engelhardt, Phelps, and Risk (Phys. Rev., 135A: 1566(1964)) on the absolute cross sections for excitation of electronic states of N_2. Numerical solutions were obtained for the case when the distribution function is determined entirely by the electric field and inelastic collisions with nitrogen molecules. The iteration procedure was found to converge within 10 or fewer iterations. One of the calculated distribution functions is in good agreement with a distribution function calculated by Engelhardt et al. for similar conditions. (ATD)

3086 POTENTIAL OSCILLATIONS OF A CYLINDRICAL CHARGED PLASMA CARRYING A CURRENT. Rosinskii, S. E.; Rukhlin, V. G. (Lebedev Inst. of Physics, Moscow). Zh. Tekh. Fiz., 37: 1401-13(Aug. 1967). (In Russian).

The kinetic equations were used with a self-consistent Maxwell field and no collision terms to discuss the stability of a plasma filament carrying an electric current. The effects of the azimuthal magnetic field due to the current and of a possible radial electric field due to uncompensated charge in the plasma are taken into account. The equilibrium ion and electron distribution functions are derived for an isothermal plasma filament. The linearized kinetic equations for perturbations of these equilibrium distribution functions are solved under the assumptions that the magnetic field perturbation is zero, the electric field perturbation is the gradient of a scalar, and the Larmor drift velocities of the plasma particles are small compared with their thermal velocities. From this solution to the linearized kinetic equation there is derived an expression for the dielectric constant of the plasma, and this expression is employed to discuss the oscillations of the plasma in the zeroth order of the geometric optics approximation. Criteria are unstable only in a nonisothermal plasma. The most significant instability under the assumed conditions is found to be are unstable only in a nonisothermal plasma. The most significant instability under the assumed conditions is found to be flute instability of the constriction type (the electric potential perturbation independent of the azimuth angle). This instability cannot be stabilized by limiting the size of the plasma filament, but a radial electric field due to uncompensated charge in the plasma tends to stabilize it. It is shown that under the conditions of the present calculations the effect of the curvature of the magnetic lines of force cannot be taken into account by the introduction of an effective gravitational field equal to the product of the square of the ion thermal velocity by the curvature of the lines of force. (ATD)

3087 SURFACE POTENTIAL WAVES IN A MAGNETIZED PLASMA. Pakhomov, V. I.; Stepanov, K. N. Zh. Tekh. Fiz., 37: 1393-1400(Aug. 1967). (In Russian).

The propagation of surface waves on the plane boundary between a semi-infinite magnetized plasma and the vacuum in the limiting case of low-phase velocity is treated when the surface waves become potential waves. The calculations are performed for arbitrary direction of the external magnetic field and arbitrary propagation direction of the surface waves. The plasma is treated as cold, i.e., it is assumed that the phase velocity of the waves is much higher than the thermal velocities of the plasma particles and that the wavelength is much greater than the Larmor radii of the particles. The authors first discuss the case of a sharp plasma–vacuum boundary, treating separately the cases of high-frequency surface waves when only the electron motions need be considered, and low-frequency waves when the ion motions must be taken into account. The corresponding dispersion equations are derived and their roots are discussed. Formulas are derived for the frequency and damping of the surface waves as functions of the relevant parameters, including the angle between the external magnetic field and the plasma surface and the angle between the propagation direction of the waves and the component of the external magnetic field in the plane of the plasma surfaces. It is found that in weak magnetic fields there are possible two surface potential waves, whereas in strong magnetic fields there can be no surface potential waves. As a function of depth within the plasma, the field of the surface waves, in addition to decreasing exponentially, undergoes spatially periodic oscillations, except when the magnetic field is perpendicular to the plasma surface or the propagation direction is perpendicular to the component of the magnetic field in the plasma surface. The authors then discuss the case when the plasma density falls continuously to zero in a layer whose thickness is finite but small compared with the wavelength. In this case resonance effects are possible and these are calculated. The effect of space dispersion (due to the thermal motions of the plasma particles) is to remove the singularity in the field due to the plasma resonance. (ATD)

3088 COLLISIONS IN A TURBULENT PLASMA. Makhan'kov, V. G.; Tsytovich, V. N. Zh. Tekh. Fiz., 37: 1381-6(Aug. 1967). (In Russian).

A nonlinear dispersion equation derived from a kinetic equation with a collision term of the form $-C(F-f_0n/n_0)$, where C is the effective electron collision frequency, f is the electron distribution function, f_0 is the Maxwell distribution function, n is the electron density, and n_0 is the equilibrium value of n, was used to discuss the effects of collisions on the nonlinear interaction of random oscillations in a turbulent plasma. The calculations were undertaken to explore the intermediate region between the collision-free plasma limit, where the nonlinear effects give rise to a spectral transfer of the oscillations from the region of low phase velocities to the region of high phase velocities with a resulting increase in the scale of the turbulence, and the hydrodynamic limit, where the opposite effect takes place. It is shown that collisions can significantly affect the interactions of Langmuir waves in the plasma. In the region of high collision frequencies the most significant effect is a nonlinear change in the dispersion characteristics of the plasma waves, and the spectral transfer effects are relatively small. Change in the direction and intensity of the spectral transfer is also possible in the region of low collision frequencies (collision frequency much smaller than the ratio of the electron thermal velocity to the wavelength), but the result depends significantly on the nature of the collisions. It is concluded that a theory that takes collisions into account by means of the Landau integral should be employed to treat the particle collisions in a fully ionized plasma. (ATD)

3089 A CONTRIBUTION TO THE TECHNIQUE OF INVESTIGATING SPIRALLING DISCHARGES. Lukac, P. (Komensky Univ., Bratislava). Czech. J. Phys., B17: 1038-40(1967).

Experimental investigations are described of an impulsive discharge of spiraling character. The dependence is given of the change of the spiraling discharge shape on the width of the impulsive discharge. It is pointed out that this dependence may serve as part of the technique of investigating spiraling discharges and the constricted positive column of a glow discharge. (auth)

3090 THEORY OF MICROWAVE DETECTION BY A DISCHARGE. Kantorek, P. (Purkyne Univ., Brno). Czech. J. Phys., B17: 1021-37(1967).

A compact theory of the hitherto only slightly explored effect of modulated electromagnetic microwave field detection in a glow discharge is discussed. Apart from theoretical analyses aimed at maximum possible generality and applicability also for other types of discharges, the most important results of experimental verifications are presented. The whole theory is divided into two parts: the macroscopic part where the discharge is studied as a disrupted macroscopic system, and the microscopic one dealing with the change in the discharge structure caused by a microwave field. Apart from discovering the mechanism of the detection effect, the theory also provides possibilities of application for plasma diagnostics. (auth)

3091 NONLINEAR EFFECTS AND THE TRANSFORMATION OF WAVE ENERGY IN AN INHOMOGENEOUS PLASMA. Jungwirth, K.; Vaclavik, J. (Inst. of Plasma Physics, Czechoslovak Academy of Sciences, Prague). Czech. J. Phys., B17: 1012-20 (1967).

The following problem is considered: under what conditions does the quasi-linear transformation of waves in plasma with an inhomogeneous beam remain a dominant effect if the nonlinear interaction of waves is respected. It is shown that in the region of densities $\omega_p^2 \lesssim \omega_B^2$ the nonlinear interaction between the high-frequency and the newly excited waves can already affect the initial stage of the process and can result in the establishment of the Rayleigh–Jeans distribution for the two groups of waves. If, on the other hand, the low-frequency waves grow first with a quasi-linear increment, the nonlinear transformation of energy inside a group of low-frequency waves is again apt to affect substantially their final amplitude and thus also the total amount of energy that can be transformed into those waves. The conditions under which a particular nonlinear effect predominates are derived for various characteristic values of density of a cold plasma. (auth)

3092 NEGATIVE ABSORPTION OF ELECTROMAGNETIC WAVES AT THE CYCLOTRON RESONANCE OF PLASMA ELECTRONS. Durcek, J. (Transport Coll., Zilina, Czech). Czech. J. Phys., B17: 1005-11(1967).

The quantum interpretation of the negative absorption of electromagnetic waves at the cyclotron resonance of plasma is given, and the conditions under which the negative absorption takes place are examined. (auth)

3093 ON THE STATIONARY STATE OF A PLASMA IN MAGNETOSTATIC AND POTENTIAL FIELDS. II. Klima, R. (Inst. of Plasma Physics, Czechoslovak Academy of Sciences, Prague). Czech. J. Phys., B17: 996-1004(1967).

The density distribution on the lines of force of the magnetostatic field is established under certain simplifying conditions for a plasma bounded by a combination of a magnetostatic and a potential field. The distribution functions of the particles, too, are determined for some of the cases being examined. It is found that certain nonlinear effects given by the action of the averaged high-frequency forces in the plasma can occur in experiments concerning the magnetoacoustic resonance of the plasma column. (auth)

3094 EXCITATION OF ION CYCLOTRON AND ELECTRON CYCLOTRON WAVES BY BEAMS OF CHARGED PARTICLES. Preinhaelter, J. (Inst. of Plasma Physics, Czechoslovak Academy of Sciences, Prague). Czech. J. Phys., B17: 987-95(1967).

The instabilities of the electrostatic waves of a hot plasma in a magnetic field, excited by beams of charged particles, have been studied in some special cases within the framework of the linear theory. We are interested in short-wavelength oscillations with a transverse wavelength comparable with the Larmor radius of ions or electrons, with frequencies in the vicinity of the harmonic cyclotron frequency of ions or electrons. Expressions have been derived for the increments of these instabilities in the case of a beam with an "isotropic" distribution function in the velocity space, as well as with an anisotropic distribution function. The influence of the beam temperature on the character of the instabilities and the conditions of formation of the instabilities are discussed, and the order of magnitude of the increments is estimated. (auth)

3095 NONLINEAR EFFECT OF ALTERING THE ZEROTH ORDER DENSITY DISTRIBUTION OF A PLASMA. Hsuan, H. C. S.; Ajmera, R. C.; Lonngren, K. E. (Univ. of Iowa, Iowa City). Appl. Phys. Lett., 11: 277-9(Nov. 1, 1967).

By increasing the power of an incident microwave signal on the positive column of a mercury vapor discharge, one observes a nonlinear response. These phenomena can be explained as being due to an alteration of the density which is caused by the externally applied field. (auth)

3096 INFLUENCE OF THE ELECTRON TEMPERATURE GRADIENT ON THE SPACE-CHARGE FIELD IN A DC DISCHARGE. Pekarek, L.; Rohlena, K. (Inst. of Physics, Prague). Czech. J. Phys., 17: 856-66(1967).

The deviations of the space-charge field from its equilibrium value in the dc discharge plasma is investigated, taking into account the influence of changed electron temperature. Starting from the plasma equations, the corresponding steady-state solution in a linear, one-dimensional approximation is found, on the assumption that the ion density disturbance is known and given as a function of the space coordinate, constant in time or only slowly varying with time. As the changed electron temperature influences the electron density, the space-charge field disturbance is no longer restricted (within the limit of the Debye screening length) by the dimension of the positive ion disturbance as is the case of the temperature uninfluenced field. The space charge field now extends widely out of the place of the ion disturbance, the extension being given by the dimension of the electron temperature relaxation length, which in order of magnitude equals the quantity $l_1 = 2U_{e0}/E_0$. A solution in a closed analytical form is found in the case of a quasi-neutral plasma. Even in this case of zero Debye length, temperature lengthening of the space-charge field relaxation takes place. The appropriate numerical examples are given for the case of final (non-zero) Debye length. (auth)

3097 WAVE PROPAGATION IN A PLASMA WITH ANISOTROPIC PRESSURE. Sharma, S. R. (Univ. of Rajasthan, Jaipur, India). Can. J. Phys., 45: 3189-98(Oct. 1967).

Wave propagation in an unbounded, magnetoactive, one-component plasma is considered with the help of modified Burgers equations. The pressure is assumed to be anisotropic and the effect of collisions on the wave propagation is examined. New modes of propagation have been reported in which the magnetic field and pressure anisotropy play an important role, while the electrostatic forces are comparatively less important. For the collisionless case, under certain conditions, new resonances appear in the transverse wave propagation, the resonant frequency being dependent upon the anisotropy parameter β. Cases have been pointed out where spatial instabilities may occur for certain values of β and the collision frequencies. It is further shown that the collisions may also offset the velocity–space instabilities which occur in a plasma with anisotropic pressure. (auth) (Canada)

3098 SCREENING OF A POINT IMPURITY IN THE SURFACE REGION OF AN ELECTRON GAS. Gadzuk, J. W. (Massachusetts Inst. of Tech., Cambridge). Solid State Commun., 5: 743-6(Sept. 1967).

A Green's function formalism is described for calculating screening charge densities around point impurities on bounded electron gas surfaces. A numerical calculation indicates that surface impurity Friedel oscillations occur over a much longer range than for bulk impurities. (auth) (UK)

3099 A STUDY OF THE CHARACTER OF MOVING STRIATIONS IN A PLASMA AFFECTED BY A STRONG HF FIELD. Sicha, M. (Charles Univ., Prague). Czech. J. Phys., 17: 867-73(1967).

Investigations of moving striations in a positive column energetically affected by a strong hf field are reported. It was found that a distinct change in striation parameters, i.e., a decrease in the amplification factor and phase velocity, occurs in a region where the additional electric field brings about an increase in intensity of plasma-creating processes. A phenomenological explanation of this effect is given, based on the knowledge of moving striations hitherto acquired. (auth)

3100 POTENTIAL PRECISION OF PLASMA PARAMETERS ESTIMATION BY METHODS OF MATHEMATICAL STATISTICS. Terpugova, N. S. (Siberian Physical-Technical Inst., Tomsk, USSR). Izv. Vyssh. Ucheb. Zaved., Fiz., No. 6, 48-53(1967). (In Russian).

The method of mathematical statistics (a method of moments) was used for estimating the shift and width of non-reabsorbed spectral lines and for determining the optical density and non-homogeneity of the source of the experimentally obtained spectral profile altered by reabsorption and other processes. (tr-auth)

3101 NONADIABATIC TEMPERATURE DISTRIBUTIONS BEHIND DETACHED SHOCKS. Bluston, H. S. (Grumman Aircraft Engineering Corp., Bethpage, N. Y.). AIAA (Amer. Inst. Aeronaut. Astronaut.) J., 5: 2061-2(Nov. 1967).

A perturbation solution is obtained as a power series in T (radiative coupling coefficient), and the absorption effects are taken into account. The range of T values for which this solution is valid is established as a function of distance behind the shock. (M.O.W.)

3102 EXCITATION OF LONGITUDINAL AMBIPOLAR SOUND IN A GAS DISCHARGE PLASMA IN A MAGNETIC FIELD AT LOW PRESSURE. Vladimirov, V. V. (Inst. of Physics, Kiev). Zh. Eksp. Teor. Fiz., 53: 1453-60(Oct. 1967). (In Russian).

It is shown that in a system in which removal of ions at the ends in a longitudinal ambipolar electric field is predominant, excitation of modes of longitudinal ambipolar sound or waves whose phase velocity is of the order of the rate of removal of the ions in the ambipolar field should be possible. The excitation is due to ion drift in the magnetic field. These results permit one to interpret the well known results of Vlasov on excitation and modification of ion sound modes. (auth)

3103 THERMODYNAMICS OF A DENSE PLASMA. Pichakhchi, L. D. (Inst. of Thermophysics, Novosibirsk, USSR). Zh. Eksp. Teor. Fiz., 53: 1461-7(Oct. 1967). (In Russian).

The classical equations of motion of a system consisting of a small number of electrons and ions are integrated numerically under the assumption that for a distance $r = r_1$ between the electron and ion the electron is elastically reflected from the ion. It is shown that for $r_1 \approx 0.5 \times 10^{-8}$ cm the Coulomb interaction potential energy and the plasma pressure on the wall calculated from the momentum transferred to the walls in elastic collisions are the same as the values obtained in the Debye approximation for values of T and n (T is the temperature and n the concentration of the electrons) for which the total plasma energy is positive. This range of T and n values is restricted from below the curve $T = T_0(n/n_0)^{1/3}$, $T_0 = 13800°K$, $n_0 = 2 \times 10^{20}$ cm^{-3} along which the pressure of the Coulomb plasma is twice as small as the pressure of an ideal plasma ($p_{id} = 2nkT$) for the same parameters. The mean free path in a dense plasma is found. It turns out to be smaller by an order of magnitude than the quantity l given by the formula containing the Coulomb logarithm. (auth)

3104 DISPERSION LAW AND NONLINEAR INTERACTION BETWEEN LANGMUIR WAVES IN A WEAKLY TURBULENT PLASMA. Gorbunov, L. M.; Timerbulatov, A. M. (Lebedev Inst. of Physics, Moscow). Zh. Eksp. Teor. Fiz., 53: 1492-8 (Oct. 1967). (In Russian).

The correction to the Langmuir wave frequency due to nonlinear coupling between the waves with various wave vectors in a weakly turbulent plasma is found. It is shown that under certain conditions this correction should by taken into account in describing the time variation of the energy spectrum of the Langmuir waves. (auth)

3105 ION HEATING IN THE EXCITATION OF MAGNETOACOUSTIC OSCILLATIONS IN A PLASMA. Kovan, I. A.; Spektor, A. M. Zh. Eksp. Teor. Fiz., 53: 1278-86(Oct. 1967). (In Russian).

Experiments on heating of magnetoacoustic waves in a uniform magnetic field are described. The gas kinetic pressure nT measured on the basis of the diamagnetic effect is, under typical conditions ($n_e \approx 10^{13}$ cm^{-3}, $H_0 \approx 2$ kOe, $T_e \approx 10$ eV), of the order of 10^{-5} eV/cm^3. It is shown that the plasma pressure is due to protons whose mean thermal energy is $T_i \sim 100$ eV. The mechanism of ion heating is discussed. (auth)

3106 THEORY OF TURBULENT ACCELERATION OF CHARGED PARTICLES IN A PLASMA. Tverskoi, B. A. (Moscow State Univ.). Zh. Eksp. Teor. Fiz., 53: 1417-30(Oct. 1967). (In Russian).

Scattering, diffusion, and acceleration of nonrelativistic charged particles in a turbulent plasma are considered. The turbulence is assumed to be hydromagnetic and its main scale is much greater than the Larmor radii of the accelerated particles. It is shown that if the pulsation spectrum $dh^2/dk \sim k^{-\nu}$ then for any ν scattering is due to cyclotron resonance; for $\nu > 2$ acceleration is determined by the Fermi mechanism and for $\nu < 2$ the Fermi mechanism as well as cyclotron resonance are significant. In an unlimited plasma, acceleration leads to growth of the turbulence internal scale and to a corresponding decrease of the number of accelerated resonance particles. A stationary distribution is established in a restricted plasma and dissipation of turbulence energy is due to diffusion of the most energetic particles from the turbulent region. Turbulent diffusion and particle acceleration on the sun and in interstellar space are considered. The equilibrium spectrum of hydromagnetic pulsations $dh^2/dk \sim k^{-2}$ is derived from the experimental data. The diffusion coefficient and energy spectra of the accelerated particles are calculated and the relation between the rate of turbulent energy dissipation and the parameters of the pulsation spectrum is estimated. (auth)

3107 STABILITY OF AN ELECTRON BEAM WITH A VELOCITY GRADIENT. Kostin, V. M.; Timofeev, A. V. Zh. Eksp. Teor. Fiz., 53: 1378-87(Oct. 1967). (In Russian).

Phenomena arising during relative slipping of plasma layers are studied in the simplest case of an electron current with a linear velocity profile in a strong longitudinal magnetic field. It is shown that in this case the plasma is stable and the initial disturbances decay in time according to the power law $t^{-\alpha}$ ($\alpha > 0$). (auth)

3108 CONTRIBUTION TO THE QUANTUM THEORY OF KINETIC AND RELAXATION PROCESSES. Peletminskii, S. V.; Yatsenko, A. A. (Physical-Technical Inst., Kiev). Zh. Eksp. Teor. Fiz., 53: 1327-39(Oct. 1967). (In Russian).

It is assumed that during a relatively short time τ_0 reduction of description occurs in a system described by a Hamiltonian $\mathcal{H} = \mathcal{H}_0 + V$. The dependence of the density matrix ρ on time for $t \gg \tau_0$ is determined only by the dependence of some parameters γ_k on time. In most cases the reduction of the description of the system as well as the form of the parameters themselves (γ_k) is due to separation from the total Hamiltonian of the system $\mathcal{H}$ of relatively strong interactions $\mathcal{H}_0$ which, however, possess certain symmetry properties of the strong interaction define the set of parameters γ_k which describe the system state for $t \gg \tau_0$. An integral equation is derived for the density matrix $\rho(\gamma)$ in which the boundary conditions for $t \to +\infty$ are taken into account. Likewise, equations are derived which describe the time dependence of parameters γ_k. As an illustration of application of the general scheme some kinetic equations for γ_k are obtained in the second approximation in perturbation theory with respect to the weak interaction V and a deduction of the quantum kinetic equation in the low-density approximation is presented. (auth)

3109 DESTRUCTION OF THE ANOMALOUS SKIN LAYER IN A TURBULENT PLASMA. Skoryupin, V. A. Zh. Eksp. Teor. Fiz., 53: 1213-17(Oct. 1967). (In Russian).

Results of an experimental investigation of passage of a high-frequency probing electromagnetic signal ($f = 3 \times 10^9$ cps) through a turbulent plasma are presented. It is found that the observed thickness of the skin layer of a turbulent plasma exceeds the theoretical thickness c/ω_{pe} by 16 times and the thickness of the dissipative skin layer by ~6 times. Increase of the thickness of the turbulent plasma skin layer is apparently due to the high-frequency probing signal being carried into the plasma by Langmuir oscillations. (auth)

3110 MOTION OF CHARGED PARTICLES IN AN AXIAL-NONSYMMETRIC MIRROR TRAP. Dubinina, A. N.; Yudin, Yu. N. Zh. Eksp. Teor. Fiz., 53: 1206-12(Oct. 1967). (In Russian).

The confinement time τ of electrons in an axial-nonsymmetric magnetic mirror trap is investigated experimentally. The value of the critical nonadiabaticity parameter ρ_L/R is determined and found to be close to that of the nonadiabaticity parameter for an electron moving in an axial-symmetric trap. The result obtained apparently permits one to affirm that the degree of nonadiabaticity in a trap is characterized by the parameter ρ_L/R and not by the deviation from symmetry of the magnetic field. (auth)

3111 REVIEWS OF PLASMA PHYSICS. VOLUME 3. Leontovich, M. A. (ed.). New York, Consultants Bureau, 1967. 332p. Translated from Voprosy Teorii Plazmy by Herbert Lashinsky.

Separate abstracts were prepared for the 4 included sections. (M.O.W.)

For abstracts of individual sections see: 3112–3114 and 3140.

3112 ELECTROMAGNETIC WAVES IN A PLASMA. Shafranov, V. D. pp 1-157 of Reviews of Plasma Physics. Leontovich, M. A. (ed.). New York, Consultants Bureau, 1967.

The oscillations of a plasma are described by the self-consistent equations of motion of the particles (or the appropriate kinetic equations) together with Maxwell's equations. If the oscillations are linear this entire system of equations can be reduced to a single Maxwell equation in which the charge density and current density are expressed as linear functions of the electric field by means of the dielectric tensor $\epsilon_{\alpha\beta}(k,\omega)$; this tensor is computed beforehand from the equations of motion. (M.O.W.)

3113 OSCILLATIONS OF AN INHOMOGENEOUS PLASMA. Mikhailovskii, A. B. pp 159-227 of Reviews of Plasma Physics. Leontovich, M. A. (ed.). New York, Consultants Bureau, 1967.

The theory includes discussions on: dielectric constant of inhomogeneous plasma, drift instability of a plasma, methods for investigating oscillations in inhomogeneous plasma, drift instabilities in a plasma in a sheared magnetic field, flute instability of a plasma with finite ion Larmor radius, and drift excitation of flute instabilities. (M.O.W.)

3114 SYMMETRIC MAGNETOHYDRODYNAMIC FLOW AND HELICAL WAVES IN A CIRCULAR PLASMA CYLINDER. Solov'ev, L. S. pp 277-325 of Reviews of Plasma Physics. Leontovich, M. A. (ed.). New York, Consultants Bureau, 1967.

The theory includes discussions on: stationary helical flow, helical waves, stability of a cylindrical plasma jet in a magnetic field, nonlinear longwave axisymmetric oscillations of a plasma cylinder, nonlinear helical waves, and linear waves in a compressible plasma. (M.O.W.)

3115 ONE-DIMENSIONAL FREE EXPANSION OF A COLLISIONLESS PLASMA. Hiroshige, Yasushi. Los Angeles, Univ. of Southern California, 1967. 128p.

Thesis.

The free expansion of a plasma is usually pictured as combination of free-streaming ions and an oscillating electron fluid. In the present work, this conjecture is tested for the case of the one-dimensional expansion of a collisionless plasma initially in thermal equilibrium and confined between two perfectly reflecting planes. Two methods of solutions are used. The first method is an approximate method based on Vlasov's equations and the second method is a computer experiment using the sheet model. For the approximate method, an assumption is made that the velocity distribution function is constant at the one remaining boundary. It is shown that this assumption is good for expansion times less than L_0/V_{th}, where L_0 is the initial confinement length and V_{th} is the ion thermal velocity. With this assumption the space averaged Vlasov set of equations is solved for the average, or the zeroth order, motion. The first four velocity moments are then taken. The first moment yields the coupled momentum equations for the two components. The momentum equations are uncoupled by expanding the solution in terms of the electron–ion mass ratio. In the lowest order, the momentum equation for the ion component reduces to the free-flow equation and the electron momentum equation becomes the linear oscillator equation with natural frequency at the electron plasma frequency. Higher-order effects appear first in the electron component when the density variation becomes appreciable. For the computer experiment, the sheet model used may be compared to a series of parallel-plate capacitors free to move through each other along a common axis perpendicular to the plates and under the influence of its self-consistent electric field. A total of 400 sheets equally divided between electrons and ions are used. The initial velocity distributions for both components are drawn from the Gaussian distribution. The initial spatial distribution is made random by placing the sheets at equal intervals and then choosing the sign of each successive sheet from the uniform distribution. For the actual experiment, the trajectories of each of the individual sheets are computed and then at various times, ensemble averages are taken to obtain the first four velocity moments. The two methods of solutions show good agreement for the ion component in the zeroth-order motion to the end of the computer run which was about 4 electron plasma periods or $\frac{3}{4}$ ion plasma period for the mass ratio used here. The electron component in the zeroth-order motion shows good agreement to about 3 electron plasma periods and then higher-order effects become appreciable. It is concluded that for $t < L_0/V_{th}$, the behavior of the ion component of the freely expanding plasma in the zeroth order can be predicted from the dumbbell model in which this component follows the center of mass of the system which is acted on by the sum of electron and ion pressures at the boundary. The electron component in the zeroth order can be assumed to follow a damped sine wave with the natural frequency at the electron plasma frequency and the damping determined from the hysteretic effect in the restoring force due to the spatial density variation. The spatially dependent, or the higher order, motion for the ion component obtained from the computer experiment shows an average trend which follows the exact free-flow solution. For the electron component, the sample size was not large enough for meaningful average. (Disser. Abstr.)

3116 INTERACTION OF PLASMAS AND RADIATION. (PARTS I–III). Murphy, Brian Logan. New Haven, Yale Univ., 1966. 96p.

Thesis.

Three aspects of a system composed of electrons, atoms (or ions), and electromagnetic radiation are studied. The central issue treated is that of the coupling between the charged particles of the plasma and the radiation field. The harmonic fields generated when the frequency of electron collisions with neutral atoms is modulated by a microwave field are determined. The starting point of the calculation is the Boltzmann equation. The classical circulation of energy between an electron and the radiation field is investigated using the methods of Prigogine and his collaborators. This phenomenon is found to be similar to the virtual processes of quantum electrodynamics in that the electron's properties are altered. The possibility that radiation of optical frequencies may act in a manner analogous to the pumping field of a conventional atomic maser and thereby produce continuous amplification of microwave radiation is considered. Here the treatment proceeds from the definition of Einstein coefficients in the continuum. (Disser. Abstr.)

3117 LOWER HYBRID RESONANCE IN A FINITE-LENGTH PLASMA. Mills, George Scott. Austin, Tex., Univ. of Texas, 1966. 69p.

Thesis.

A theoretical treatment of the propagation of the extraordinary wave across the static magnetic field in a dense plasma has been extended to the case of a plasma which is finite in the direction of the magnetic field. This model indicates that propagation at less than 90° to the magnetic field, required in order to match the boundary condition at the ends, results in values of ω_0/ω which are less than 1. $\omega_0 = (\omega_{ci}\omega_{ce})^{\frac{1}{2}}$ is the lower electron–ion hybrid frequency. The decrease in ω_0/ω is increased by further reduction in plasma length as well as by increase of the ion mass. Marginal decreases in ω_0/ω, determined from this analysis for a hydrogen plasma and observed in hydrogen ring discharges as an increase in the loading of the oscillator, did not allow conclusive comparison of theory and experiment. The present work involves comparison between theory and experiment for the cases of argon and cesium plasmas. Calculation of ω_0/ω for argon results in values between 0.5 and 0.6 while experimental values range from 0.45 to 0.67. The agreement is considered good in the light of the experimental errors involved. In the case of the cesium plasma the computed values range from 0.14 to 0.21 as do the experimental values. The better agreement is largely due to a much greater amount of experimental data available. In a comparison of the theory with a specific experimental case, the agreement is within 16% if the inhomogeneity of the magnetic field is accounted for. When the plasma is generated by contact ionization as well as by radio-frequency energy, the only observable effect is an increase in the plasma density and a slight shift upward in the value of ω_0/ω corresponding to this density increase. The good agreement between these experiments, in which significant deviations of ω_0/ω from 1 were encountered, and the theory used to obtain the calculated values confirms the validity of such a simple model. This experimental confirmation of the theory opens the way for its application to further studies of the lower hybrid resonance, particularly in the area of non-collisional heating effects. (Disser. Abstr.)

3118 BOUNDARY LAYER STRUCTURE IN A SHOCK-GENERATED PLASMA FLOW. Knoos, Per Stellan. Stanford, Calif., Stanford Univ., 1966. 213p.

Thesis.

The structure of some laminar boundary layers in high-density, shock-heated, 1-eV argon plasma flows is investigated theoretically and experimentally. The theoretical analysis is based upon a three-fluid continuum formulation. The boundary layer equations are solved numerically on a digital computer by a finite difference technique for the case of thermochemical equilibrium and no applied electromagnetic fields, neglecting radiation. The induced electric field is taken into account, and is shown to be of fundamental importance. It strongly couples the diffusive motions of the electron and ion fluids into the ambipolar type, except in a sheath region adjacent to the wall. Argon transport properties calculated from simple kinetic theory are used in the analysis. It is demonstrated that important parameters, such as the Prandtl number and the density–viscosity product are not constant, but vary one or two orders of magnitude in the argon plasma boundary layer. This is in sharp contrast to results for classical, non-ionized boundary layers. Detailed solutions are presented for the simple Rayleigh's boundary layer (forming over an infinite flat plate with an impulsively started motion in its own plane), and the shock-tube side-wall boundary layer (forming behind a plane, ionizing shock wave moving over an infinite, plane wall). Even in terms of appropriate similarity parameters solutions for, e.g., velocity and temperature profiles exhibit strong dependence upon the free stream conditions. The assumptions of chemical and temperature equilibria are checked in a rigorous way from the equilibrium solutions. It is found that at 1-atm pressure equilibrium ionization will typically not be present in the argon boundary layers at temperatures below 9000°K. Similarly, due to ineffective energy transfer rates between the electron and the heavy particle fluids and different electron and ion–atom thermal conductivities, the electron temperature will deviate from the heavy-particle temperature in the same temperature region. The electron temperature is calculated in a linearized model and is found to be larger than the ion–atom temperature for the present plasma. It is felt that the calculations which assume thermochemical equilibrium throughout the boundary layer give almost correct velocity and atom-temperature profiles, since the degree of ionization is small in the actual nonequilibrium region and hence the atom properties are of most importance here. The shock tube side-wall boundary layer is studied experimentally with a new simple quantitative schlieren technique. The refraction of light passing through 1-mm-thick boundary layers is measured for two separated wavelengths from displacements of two shadows formed by inclined thin wires in point source light, which is reflected in an "off-axis" (large spherical aberration) concave spherical mirror. The experiments, which are of exploratory nature only, clearly demonstrate the feasibility of the technique in analyzing plasma boundary layer flows. Measured electron density profiles in the high temperature region of the side-wall boundary layers agree within experimental errors with those calculated from the equilibrium boundary layer theory. (Disser. Abstr.)

3119 PROPAGATION OF ELECTROSTATIC DISTURBANCES IN FINITE-TEMPERATURE PLASMAS. Ferrar, Carl McAlvay. Storrs, Conn., Univ. of Connecticut, 1966. 104p.

Thesis.

An investigation is described in which the propagation of electrostatic disturbances in finite-temperature plasmas is demonstrated experimentally. It is shown theoretically that these disturbances can be produced in a plasma by assigning a small alternating velocity to the plasma boundary. Based on this result; experimental techniques are developed for production and measurement of the disturbances in argon plasmas with plasma frequencies of order 10^7 to 10^8 radians per second and Debye lengths ranging from one to several millimeters. The experimentally determined propagation characteristics of the disturbances are found to be in good agreement with theoretical predictions. (Disser. Abstr.)

3120 LANDAU WAVES. Simonen, Thomas Charles. Stanford, Calif., Stanford Univ., 1967. 154p.

Thesis.

A comprehensive theoretical and experimental study was made of Landau's electrostatic space-charge waves in isotropic hot electron plasmas. The signal spreading from a steadily oscillating dipole sheet is described by an electrostatic Green's function which is synthesized from the spectrum of Landau waves. Numerical results for a Maxwellian plasma show that this signal is rejected below the plasma frequency, penetrates deeply into the plasma slightly above it, and is strongly damped for higher frequencies. Pairs of parallel plane grids immersed into a plasma provide a scheme for launching and detecting Landau waves. This system is described by N-terminal impedance equations from which transconductances and voltage transfer ratios between gridded rf probes are calculated. Results show an optimum width of about 5 Debye lengths for modulating and detecting gaps. Close-range transmission between rf probes is characterized by the exponentially decaying fundamental Landau wave. At larger distances the signal decays as $\exp(-1/x^{\frac{1}{2}})$ due to the persistence of higher order Landau waves, or even more slowly, as $1/x$, if rf currents circulating through ground connections become important. The experiment employs gridded rf probes to excite and detect electrostatic waves within a quiescent collision-free sodium plasma at thermodynamic equilibrium. Exponentially decaying waves with phase velocities between 1.5 and 3 times the electron thermal speed 3×10^7 cm/sec are observed at frequencies between $\omega_p < \omega < 2.5\ \omega_p$. As plasma density and rf frequency are varied the measured wavelengths and spatial damping rates are scaled to Debye length using independent Langmuir probe data. Full agreement is found between the experimental results and the fundamental solution of Landau's dispersion relation. (Disser. Abstr.)

3121 GAP COUPLING TO BEAM–PLASMA SYSTEMS WITH APPLICATIONS TO AMPLIFIERS. Narayan, Subrahmanyam Yegna. Ithaca, N. Y., Cornell Univ., 1967. 190p.

Thesis.

A linearized small-signal theory of gap coupling to a waveguide containing an anisotropic plasma is presented. The plasma may be cold, stationary, contain drifting components, or may have a thermal velocity distribution. The theory allows computation of the various electromagnetic fields, current modulation, and the kinetic voltage resulting from the gap excitation. The electronic loading admittance of the gap is also calculated. In view of its application to beam–plasma amplifiers, computations have been made for the model of an electron beam flowing through a gapped waveguide filled with a cold, collisionless plasma, the whole system being immersed in an axial, static, magnetic field. Both the inductive-medium regime and the traveling-wave regime are considered. In the inductive-medium regime, the coupling coefficients to the growing wave modes have been calculated under two approximations: (1) the electron beam filling the plasma waveguide, and (2) a very thin electron beam. The model of the beam filling the waveguide agrees with Chorney's one-dimensional theory. The thin-beam model is more realistic and predicts considerable coupling enhancement when the operating frequency is equal to the plasma frequency. Also the regimes of high gain and good coupling are shown to overlap, and are thus

compatible. The admittance calculation shows that at the plasma frequency, the gap conductance reduces identically to that of a gridded gap in vacuum. This provides a physical explanation for the coupling enhancement. In the traveling-wave regime, the gap admittance of a waveguide loaded with a cold, collisionless plasma is calculated for the forward-wave, backward-wave, and evanescent-wave regions. The gap conductance is positive in the forward-wave region and can be varied over a large range of values, indicating relative ease of coupling. In the backward-wave region, the gap conductance is again positive, but the range of variation is restricted, indicating that coupling is difficult. In the evanescent-wave region the admittance is purely imaginary. An experiment on direct coupling to an inductive-medium, beam-plasma amplifier using a Penning discharge plasma in hydrogen is described. Total gains of around 20 db were obtained with virtually no coupling loss using gaps fed by singly re-entrant cavities. The initial coupling loss was around 15 db. The experiment showed that the regimes of high gain and good coupling overlap, as predicted by the theory. (Disser. Abstr.)

3122 EQUATIONS FOR GAS MIXTURES WITH APPLICATION TO THE STUDY OF SHOCK STRUCTURE IN A BINARY GAS. Goldman, Edward Ben. Providence, Brown Univ., 1966. 84p.

Thesis.

A closed set of equations is obtained for arbitrary gas mixtures. Component conservation equations are obtained by taking moments of the Boltzmann equations associated with the mixture. The momentum and energy transfer integrals that arise are evaluated and written in terms of differences in velocities and temperatures. Composite conservation equations are written for the mixture, and expressions for the composite energy, stress, and heat conduction are found. The basic set of conservation equations is closed by the constitutive relations for the stress and heat conduction of each species. These relations are obtained from a consideration of the Boltzmann equation, but this analysis is more complex than in the case of a single component gas because of the many, possibly widely varying, length scales that now enter in the approach to equilibrium. A perturbation method is presented which holds generally for any type of gas mixture. After expressions are found for the orders of magnitude of the various length scales, it is shown that only two possible theories follow from a generalized Chapman–Enskog procedure. On the one hand, we obtain the equations of classical Chapman–Enskog. However, it is now shown that these hold for a much wider set of circumstances than the original derivation. On the other hand, for situations which fall outside of this extended classical Chapman–Enskog theory, we obtain a new theory which may be regarded as a one-velocity, two-temperature theory. It is proposed that, for cases widely removed from equilibrium, the basic two fluid equations be used. As an example of these equations, a heat flow problem is solved. The structure of a shock wave in a binary mixture is studied using the general two fluid equations. The composite fluid is first shown to obey the classical Rankine–Hugoniot conditions with a properly defined composite Mach number. After a suitable normalization, the equations are solved by a perturbation method employing expansions in terms of a shock strength parameter. These solutions, which are carried to second order, are of two types. If the coefficients of the velocity and temperature difference terms in the component momentum and energy equations are both 0(1), only one temperature appears in the solution. These shocks are structured by viscosity and heat conduction with a contribution from diffusion. If the coefficient of the temperature difference is small, two temperatures appear. In this case, the shock structure is diffusion-dominated as long as the ratio of the light gas number density to the total number density is 0(1). The importance of diffusion in structuring the shock decreases as this ratio decreases. An exception to the two temperature case occurs when the order of magnitude of the shock strength parameter is less than that of the coefficient of the temperature difference (i.e., a weak shock). Even though this case will now have only a one-temperature solution, the shock structure may still be diffusion-dominated. The division of these solutions into one and two temperature cases corresponds to the division of the results of the generalized Chapman–Enskog procedure into the classical one-temperature and new two-temperature theories. (Disser. Abstr.)

3123 ON THE FLOW OF CHARGED PARTICLES. Winograd, Yeshaiahu Yehuda. Providence, Brown Univ., 1966. 168p.

Thesis.

One-dimensional unneutralized flow of charged particles in a bounded system is examined in detail for several flow models. The well-known overlap of steady state solutions, occurring in zero temperature flow approximation, is shown to reappear in the more elaborate flow approximations: collisionless flow and isothermal flow, and is proved to be unstable to infinitely small perturbations. Steady state flows in which a partial reflection of charged particles from a "virtual cathode" is assumed, are also shown to be unstable to small perturbations. While the collisionless flow approximation is solved with the aid of numerical integration (on an IBM 7070), a complete analytic solution is presented for the isothermal flow. A configuration for neutralizing a charged particle beam is examined. A steady state neutralized flow solution is shown to exist, when neutralizing a heavy ion beam with electrons, according to both isothermal and isentropic flow approximations. An effective neutralization length of the order of a Debye length, $\lambda_D = (kT/4\pi ne^2)^{\frac{1}{2}}$, is found when the ion beam velocity is less than the electron speed of sound. A steady-state oscillatory solution is obtained when the ion beam velocity is greater than the electron speed of sound. Perturbation analysis for steady state flows which deviate only slightly from a completely neutralized flow is undertaken, and such steady state flows are shown to be stable to an infinitesimal disturbance. A step disturbance in the injection velocity of the electrons is shown to propagate relative to the beam with the electron sound speed, and to decay with time, the decay, after a long time, being of the order of $t^{-\frac{1}{2}}$. (Disser. Abstr.)

3124 AN INVESTIGATION OF ELECTRONIC RECOMBINATION IN HELIUM AND ARGON AFTERGLOW PLASMAS BY MEANS OF LASER INTERFEROMETRIC MEASUREMENTS. Gusinow, Michael Allen. Urbana, Ill., Univ. of Illinois, 1966. 115p.

Thesis.

Two helium–neon laser interferometers were used to obtain the electron and neutral atom densities in an afterglow plasma. The interferometric technique utilized allows one to obtain both the spatial and temporal dependence of the electron decay. The two gases studied were helium and argon at 2 to 8 torr and 0.3 to 0.8 torr respectively. The electron density was in the range of $2 \times 10^{13} < N < 10^{15}$ cm^{-3} and the electron temperature in the range $1000 < T_e < 7000$°K. The electron temperature was measured by comparing the relative atomic line intensities and by inference from the recombination coefficient. The electronic recombination in helium, argon, and helium–argon mixtures was found to follow too closely the predictions of Bates, Kingston, and McWhirter for collisional–radiative recombination. In the range of electron temperature and density studied the recombination coefficient exhibited an approximate $T^{-\frac{1}{2}}$ dependence. The electron temperature inferred from the measured recombination coefficient indicates a pronounced electron temperature gradient across the tube which is believed to be due to electron heating effects in the afterglow. (Disser. Abstr.)

3125 FIELD OF THE ELECTRON CYCLOTRON WAVE IN A CYLINDRICAL PLASMA. Grawe, H. (Institut fuer Plasmaphysik, Garching, Ger.). 11p. (In German). (CONF-660448-7). DTIE.

From Meeting of the Professional Group on Plasma and Gas Discharge Physics, Kiel.

The dielectric tensor is given for cylindrical waves in a hot, uniform plasma and the limits of the approximation of vanishing temperatures determined. In this approximation the wave field in a metal cylinder completely filled with plasma is calculated numerically. Unlike the vacuum field, the E field has a pronounced axial component in the parameter range of interest. (auth)

3126 PLASMA WAVES AND ROTATION IN THE GAS-FED HOLLOW-CATHODE ARC. Kretschmer, C. B.; Boeschoten, F.; Demeter, L. J. (Aerojet-General Corp., San Ramon, Calif.). 25p. (CONF-670434-2). DTIE.

From 10th AFOSR Contractors Meeting on Ion and Plasma Propulsion Research, San Diego, Calif.

Mass rotation and azimuthally propagating waves have been observed in gas-fed hollow-cathode arcs having $n_e \approx 10^{14}$cm^{-3}, $T_e \approx 1$ eV, $T_i = 3$ to 30 eV, and $B_z = 1$ to 6 kG. The column rotates as a rigid body at an angular velocity of $\frac{1}{2}\,\omega_{ci}$; it is shown theoretically that at this velocity the radial density gradient has the maximum value at which equilibrium is possible in the absence of a radial electric field. This maximum gradient corresponds to an $\exp\{-r^2/(2\rho_i)^2\}$ dependence of density on radius, where ρ_i is the ion Larmor radius. The observed waves propagate in the electron drift direction exactly perpendicular to the axis of the arc, but have nonzero $k_\parallel$ because of the azimuthal field of the arc current. They are identified as resistively unstable drift waves, modified torsional Alfvén waves, and ion cyclotron waves. The drift and ion cyclotron waves occur as coherent oscillations with phase-locked harmonics, while the Alfvén waves are noncoherent. Because of the dependence of the density gradient on B_z, the drift-wave frequency is proportional to B_z and the Alfvén wave frequency is

independent of B_z. The Alfvén and ion cyclotron waves are excited by a feedback mechanism involving electron flow across the anode sheath. (auth)

Production of Plasma

Refer also to abstract 3020.

3127 (NYO-3578-1) PRODUCTION OF PLASMAS FOR THERMONUCLEAR RESEARCH BY LASER BEAM IRRADIATION OF SOLID PARTICLES. Quarterly Report, June 29-September 30, 1965. Haught, Alan F.; Polk, Donald H. (United Aircraft Corp., East Hartford, Conn. Research Labs.). Contract AT(30-1)-3578. 27p. (UARL-D-920365-1). Dep. CFSTI.

The Research Laboratories of the United Aircraft Corporation are conducting under the subject contract an investigation of plasmas for thermonuclear research produced by laser-beam irradiation of single solid particles. In these studies the focused high-intensity beam from a Q-spoiled ruby laser is used to form a high-temperature, high-density plasma from a single 10- to 50-micron-diameter solid particle of lithium hydride suspended in a vacuum environment free of all material supports. Charge collection measurements on the plasma have shown that complete ionization of the 10^{15} atoms in the lithium hydride particle is achieved, and time-of-flight studies of the plasma expansion show that average plasma energies as high as 240 eV are obtained in the laser-produced plasma. Calculations have been made of the expansion rate, temperature time history, and predicted average energy of these plasmas. These calculations extend those available in the literature to include different time histories for the incident laser pulse and an explicit account of that portion of the laser beam occupied by the expanding plasma. Also, results of these calculations have been used to select the optimum particle sizes for the pulse shape and beam focal diameter of the laser system employed. Average plasma energies have been calculated which are in reasonable agreement with those obtained experimentally. For the calculations a uniform density throughout the expanding plasma was assumed. Measurements of the ion collection as a function of time have been carried out, and the agreement obtained between the calculated and measured ion collection indicates that the uniform density model selected for the plasma expansion is a valid approximation for the laser-produced plasma. (auth)

3128 HIGH-POWER MICROWAVE NONLINEAR COUPLING TO ACOUSTIC RESONANCES IN A WARM PLASMA. Asmussen, Jes Jr.; Beyer, James B. (Univ. of Wisconsin, Madison). Appl. Phys. Lett., 11: 324-6(Nov. 15, 1967).

The nonlinear high-power coupling of microwave power to electroacoustic resonances which are at a harmonic of the driving frequency, ω_1, is discussed. Experimental results that indicate the existence of this nonlinear coupling are presented, and a one-dimensional theory which includes the thermal properties of the plasma is briefly developed. The inclusion of the temperature phenomena allows one to explain previously unexplained resonances in harmonic output. (auth)

3129 SHOCK TUBE STUDY OF THE KINETICS OF THERMAL IONIZATION. Hawkins, Herbert Ross. Berkeley, Calif., Univ. of California, 1966. 175p.

Thesis.

Measurements have been made of the rate of thermal ionization of xenon and xenon-neon mixtures. A pressure-driven shock tube fitted with an improved longitudinal microwave probe was used to monitor the time-varying electron concentration. One set of experiments at 6500°K and 3×10^{18} atoms/cm^3 was used to compare the relative efficiencies of xenon atoms. An impurity level of 0.4×10^{-6} in xenon of some easily ionized but unknown substance contributed heavily to ionization at early times. In a second set of experiments at 8500°K, the transition from atom-atom to electron-atom ionizing processes was observed at electron concentrations roughly near those predicted by Harwell and Jahn. An activation energy of approximately 4 eV is in disagreement with values found by other investigators and may be due either to uncertainty in temperature or impurity ionization. (Disser. Abstr.)

Stability of Plasma

3130 (IPPCZ-73) COMPLETE SPECTRUM OF FLUTE INSTABILITY AT LOW DENSITY. Sedlacek, Z. (Ceskoslovenska Akademie Ved, Prague. Ustav Fyziky Plazmatu). Jan. 1967. 15p. Dep.

With the plasma density profile of the tangens hyperbolicus form, the eigenvalue equation for the flute instability of a cold, rarefied plasma reduces to the hypergeometric differential equation for which the eigenvalue problem is exactly solvable. The dispersion relation thus obtained is valid for arbitrary relation of the wave number to the density gradient and covers not only the principal eigenmode but also all higher eigenmodes. The principal eigenmode turns out to be the most unstable; if it is stabilized, so are all higher eigenmodes. (auth)

3131 (UCRL-Trans-10142) STUDY OF INSTABILITIES IN THERMALLY IONIZED PLASMA. Buchel'nikova, N. S. (Akademiya Nauk SSSR, Novosibirsk. Institut Yadernoi Fiziki). Translated by T. Watt for Univ. of California, Lawrence Radiation Lab., Livermore, from a Preprint. 34p. Dep. CFSTI. JCL $3.60 fs, $1.22 mf.

A number of instabilities were investigated in thermally ionized plasma which is a convenient object for studying the plasma properties. The first class of instabilities to be investigated was concerned with dense inhomogeneous plasma. The drift-dissipative instability was observed and investigated in detail in collisional plasma in which the Larmor radius of ions ρ_i was much smaller than the linear dimensions R of the system. A state akin to drift instability was also found in collisionless plasma for $\rho_i < R$. As the ratio ρ_i/R approaches a figure greater than or comparable with unity, this instability is transformed into the instability of highly inhomogeneous plasma which gives rise to azimuthal waves whose phase velocities are equal to the velocity of ion-acoustic waves. Oblique waves for which the phase velocity of the longitudinal components approaches the velocity of ion-acoustic waves are excited in the case of low density gradients. (auth)

3132 MEASUREMENTS OF ENHANCED PLASMA LOSSES CAUSED BY COLLISIONAL DRIFT WAVES. Chu, T. K.; Hendel, H. W.; Politzer, P. A. (Princeton Univ., N. J.). Contract AT(30-1)-1238. Phys. Rev. Lett., 19: 1110-13(Nov. 6, 1967).

Measurements are reported of enhanced plasma losses caused by collisional drift waves in magnetically confined, thermally ionized alkali plasmas, based on (a) a density decrease in the central part and an increase in the outer part and outside of the plasma column, coincident with the abrupt onset of drift waves, and (b) correlation of density and plasma-potential oscillations. The enhanced loss, for a wave amplitude equal to 10% of the zero-order density, is measured to be an order of magnitude larger than the loss due to classical collisional diffusion. (M.H.R.)

3133 RADIATION INSTABILITY OF BOUNDED PLASMA. Alikhanov, S. G. Dokl. Akad. Nauk SSSR, 174: 1300-1(June 21, 1967). (In Russian).

In a plasma which is not in thermodynamic equilibrium it is possible to form a small section of relatively dense cold plasma whose size is determined by competitive processes such as absorption of radiation, thermal conductivity, and others. In a limited plasma volume with a temperature T and concentration of charged particles n, the following inequality for the characteristic size Λ is valid at sufficiently high temperatures: $\Lambda \ll \sigma T^4/(\alpha_1 n^2 T^{0.5} + \alpha_2 n^2 T^{-0.5})$. Here α_1 and α_2 are coefficients of the bremsstrahlung and Raman radiation respectively, and σ is the Stefan-Boltzman constant. With the bremsstrahlung radiation dominant, $T = T_0 (1 - t/\tau_0)^2$. Here τ_0 is the total de-excitation time of the plasma, and t is the time. Also $\tau_0 = 6T_0^{0.5}/\alpha_1 n_0$. When the Raman radiation dominates the following relation holds: $T = T_0 (1 - t/\tau_0)^{0.67}$. Here the cooling time $\tau_0 = 2T_0^{0.5}/\alpha_2 n_0$, and an expression is given for the concentration increase in the plasma bundle. The equalization of temperature due to the thermal conductivity works against the formation of a cooled bundle of plasma. The minimum critical size of the bundle is determined by equalizing the cooling time and the temperature relaxation time, that is, $\lambda_{min} = \tau_0 \chi/1.5$ nk. Here χ is the thermal conductivity of the plasma. The above conditions define the upper and lower size limits of the stability. For hydrogen $\lambda_{min} \sim 1$ cm at $T = 10$ eV and $n = 10^{18}$ cm^{-3}. (TTT)

3134 INTERNAL GRAVITATIONAL INSTABILITY IN A STRATIFIED ANISOTROPIC PLASMA. Yu, C. P.; Sanborn, J. V. (State Univ. of New York, Buffalo). Phys. Fluids, 10: 2436-41 (Nov. 1967).

The instability induced by external gravitational forces in an infinite, stratified, anisotropic plasma with a magnetic field has been studied using the Chew, Goldberger, and Low approximation. A plasma whose equilibrium properties vary with height in a horizontal variable magnetic field and a vertical gravitational field is considered. Three stability criteria are derived from the energy principle, two of which lead to the "firehose" and "mirror" instabilities found in a uniform anisotropic plasma while the third criterion is for the convective instability arising from gravity. In contrast to the isotropic case, it is found that the convective criterion depends explicitly upon the magnetic field. An increase of the magnetic field by a constant quantity shows that the plasma is more stable. The growth rates of the unstable displacements in the least stable regions are calculated using a normal mode analysis. (auth)

3135 ELECTRON TEMPERATURE INSTABILITY OF A NONUNIFORM PLASMA. Mikhailovskii, A. B. Zh. Tekh. Fiz., 37: 1365-80(Aug. 1967). (In Russian).

Instabilities of a nonuniform plasma having a nonuniform temperature distribution that arises only when the ratio of the ion Larmor radius to the transverse wavelength exceeds a critical value are described. Two such instabilities are found; one involves excitation of short wavelength Alfvén waves and the other, whose excitation is due to a perturbation of the motion of the electrons, the author calls "electronic sound". The Alfvén waves are excited only when $ndT/Tdn > 4$, and the electronic sound, only when $ndT/Tdn > 0.9$, where T and n are the plasma temperature and density, respectively. The electronic sound is characterized by a longitudinal phase velocity approximately equal to the electron thermal velocity. These instabilities are discussed in some detail; their regions of instability are delineated and formulas are derived for their increments. (ATD)

3136 CALCULATION OF STATISTICAL ENTROPY ON A NONEQUILIBRIUM PLASMA. Laval, G.; Pellat, R.; Vuillemin, M. (CEN, Fontenay-aux-Roses, France). J. Phys. (Paris), 28: 689-700(Aug.-Sept. 1967). (In French).

The Gibbs entropy of a plasma out of equilibrium is obtained by assuming small binary correlation functions and neglecting higher-order correlations. In the lowest order, a first integral of the hierarchy of equations for the reduced distribution functions is obtained. Finally, an H theorem is demonstrated for a spatially homogeneous plasma when the Balescu–Lenard kinetic equation is no longer valid. (auth)

3137 BEAM INSTABILITY (SHARP DISCONTINUITIES) OF PLASMA CURRENTS. Karchevskii, A. H.; Babichev, A. P.; Muromkin, Yu. A.; Bezmel'nitsyn, V. N. Zh. Eksp. Teor. Fiz., 53: 1195-1205(Oct. 1967). (In Russian).

It is shown that current discontinuities are observed in a straight low-current discharge ($I \approx 100$ to 400 A) under conditions when the electric field in the plasma in comparable to the critical Dreiser field. Beam instability of the current in the plasma is accompanied by heating of the electrons up to a temperature $T_e \approx 4$ to 5 keV. The density of the hot electrons is $n_r = 10^{11}$ cm^{-3} for a total plasma density $n_0 \approx 2 \times 10^{12}$ cm^{-3}. The heating efficiency depends on the configuration of the magnetic field and increases with growth of the magnetic field gradient. Confinement of a hot electron plasma by magnetic mirror traps is restricted by the development of electron cyclotron instability and in these experiments is 30 to 50 μsec. (auth)

3138 NATURE OF THREE-STAGE INSTABILITY OF A PLASMA COLUMN. Nezlin, M. V. Zh. Eksp. Teor. Fiz., 53: 1180-94(Oct. 1967). (In Russian).

The instability mechanism responsible for acceleration (heating) of ions and disruption of a current (formation of a virtual cathode) in an electron beam passing through a plasma column is investigated experimentally. It is shown that the instability is of a three-stage nature. The first instability is related to flute (centrifugal) instability of the plasma rotating under the action of an equilibrium radial electric field crossed with an external longitudinal magnetic field. The second and third stages, according to this viewpoint, are respectively related to the kinetic and hydrodynamic buildup of drift-beam instability theoretically studied previously. (auth)

3139 MEASUREMENT OF THE THRESHOLD DENSITY DURING THE APPEARANCE OF ION-CYCLOTRON INSTABILITY IN A HOT ION PLASMA. Bortnikov, A. V.; Brevnov, N. N.; Zhukovskii, V. G.; Romanovskii, M. A. Zh. Eksp. Teor. Fiz., 53: 1249-55(Oct. 1967). (In Russian).

Threshold phenomena arising in a plasma with hot ions are studied for the case when the plasma density exceeds a certain critical value. It is found that if the lifetime of the ions is small (equal to the time of flight between the mirrors) the excess of the density with respect to the critical value leads to a sharp increase of the varying electric fields in the plasma possessing frequencies equal to the ion-cyclotron frequency or its harmonics. A result of these oscillations is an increase of the flux of fast ions incident on the wall and broadening of their angular distribution as a result of which they penetrate deeper into the magnetic mirror. The threshold value of the density satisfies the criterion according to which ion-cyclotron instability due to the presence of a positive derivative in the fast-ion distribution function with respect to transverse energy ($\partial f_\perp / \partial g_\perp > 0$) must develop with a maximal increment (cyclotron cone instability). On trapping of the plasma (large ion lifetime) the high-frequency oscillations decay and groove instability sets in. (auth)

3140 THEORY OF A WEAKLY TURBULENT PLASMA. Vedenov, A. A. pp 229-76 of Reviews of Plasma Physics. Leontovich, M. A. (ed.). New York, Consultants Bureau, 1967.

The theoretical discussion includes: plasmon–particle interactions, basic equations of quasilinear theory, relaxation of plasma oscillations, growth of perturbations in an unstable plasma, interaction of a beam with a plasma, threshold for wave absorption in a plasma and turbulent heating, plasmon–plasmon interactions, three-plasmon processes, and higher-order processes. (M.O.W.)

3141 FLUTE OSCILLATIONS IN MIRROR CONFINED PLASMAS: THEORY AND EXPERIMENT. Chang, Tao-yuan. Berkeley, Calif., Univ. of California, 1966. 162p.

Thesis.

Flute oscillations in bounded, nonuniform plasmas are considered from the guiding center point of view. The effects of field curvature are replaced by generalized forces that are proportional to the parallel and perpendicular components of the particle energy. A perturbation analysis, covering all density regimes and including the finite gyroradius effects, is carried out in cylindrical coordinates. It is shown that the final equation can always be solved by a variational method. Explicit solutions in terms of confluent hypergeometric functions are also presented for a special class of density distributions. For a monoenergetic plasma, in which all ions precess coherently, there can be stable regions at both very low and very high densities. If the ions precess incoherently, due to a spread in the energy, then a new overstability emerges in the above stable regions. This overstability, whose growth rate is very small compared to its oscillation frequency, is shown to be in agreement with the observations made in neutral injection experiments. An experimental investigation of flute oscillations in a mirror magnetic field, using a potassium plasma, is described. The plasma, generated by surface ionization of potassium molecules on a tungsten cathode located at the center of the mirror magnetic field, has a density between 10^8 and 10^9 cm^{-3}. It is shown, after a derivation of scaling laws for quasi-electrostatic oscillations in plasmas, that, as far as flute oscillations are concerned, the plasma simulates a high-temperature plasma of thermonuclear interest. In the experiment, the plasma is adiabatically decompressed temporarily to reduce the short-circuit effects of the cathode. The measured quantities include: the spatial and temporal correlations of resulting oscillations, the rate of radial transport of the plasma after decompression, and the density profile of the plasma. The results are shown to be largely consistent with calculations based on a theory that takes into account the effects of finite gyroradius, the vacuum wall, the cathode, and the energy dependence of ion precessions in a mirror magnetic field. (Disser. Abstr.)

3142 NONLINEAR COMPUTER MODEL FOR LOW-BETA PLASMA INTERCHANGE INSTABILITIES. Byers, Jack Austin. Berkeley, Calif., Univ. of California, 1966. 175p.

Thesis.

A two-dimensional, two-fluid computer model capable of following the interchange modes of a low-beta plasma well into nonlinear regimes has been developed. Low-beta plasma interchange is taken to mean cooperative charged-particle motion perpendicular to an externally imposed magnetic field, $\vec{B}$, which is uniform in space and constant in time. A gravitational field, $\vec{g}$, ($\vec{g} \perp \vec{B}$) is imposed to simulate effects of $\vec{B}$ field curvature. The motion of charged particles is described entirely by guiding-center equations. Finite gyro-orbit effects are included as correction factors. The two-dimensional motion for an ion fluid and an electron fluid is carried forward in time by a finite difference solution in both space and time of the equations of continuity. The initial results obtained were details of long-time behavior of two contrasting cases in the "one-fluid" low-density regime, $K = n_i m_i / (\epsilon_0 B^2) \ll 1$: (1) a flute of Rayleigh–Taylor mode caused by $\vec{g} \cdot \nabla n < 0$, and (2) a Kelvin–Helmholtz mode caused by excess charge and a corresponding E/B velocity shear ($g = 0$). In both cases, growth observed at small amplitudes is exponential in time and checks well with linear theory; the nonlinear development, however, is strikingly different. The flute mode continues to distort the boundary layer and to force the interior of the fluid out towards the wall. The plasma is essentially nonconfined as the growth is stopped only at the bounding wall. The Kelvin–Helmholtz mode distorts the boundary layer into rotating charge bunches or vortices; when the bunches become distinct and separate, the growth essentially stops, which leaves the plasma in a distorted but confined state. The model was next applied to these same two modes with an increase in the plasma density so that $K \gtrsim 1$. This change makes the ion polarization currents become effective in causing charge separation. However, no gross changes in the nonlinear states already found were observed. The major change in both modes seems to be a better shielding of the interior of the plasma from the effects of the changes in the charge distribution in the boundary layer. The model was finally extended to examples of plasmas in "two-fluid" regimes. In the first case examined,

this regime was obtained by reducing the density to very low values so that the ion gravitational drift frequency, defined as $\omega_d = gk/(2 \cdot \omega_{ci})$, becomes comparable to the one-fluid growth rate, $\omega_g = (g \cdot \nabla n/n \cdot K)^{\frac{1}{2}}$. Linear theory shows that, when $\omega_d > \omega_g$, the competition between the two effects becomes more favorable to the drift mechanism and complete stability occurs. The computer model was applied to a case which was unstable in the linear regime but not far removed from the marginal stability condition. A finite-amplitude, nongrowing, oscillating state results. Thus, finite amplitude stability can be expected for linear regime unstable cases as the nonlinear effects slow down the basic growth mechanism to a degree sufficient such that the competing process becomes the faster mechanism. A second "two-fluid" calculation, for a flute with the competing process being finite-orbit effects, tends to show that finite-amplitude stability does occur here also, but computational stability problems have prevented completely convincing proof. (Disser. Abstr.)

3143 UHF-PLASMA INTERACTION: THE TWO-STREAM INSTABILITY OF A CURRENT-CARRYING PLASMA. Hosea, Joel Carlton. Stanford, Calif., Stanford Univ., 1966. 152p. Thesis.

The "collective" space charge interaction between the electron and ion streams of a current-carrying plasma results in the enhancement of electrostatic oscillations carried by the two streams. When the relative drift velocity between the electrons and ions exceeds a critical value of the order of the electron thermal velocity, some oscillations begin to grow exponentially in amplitude and the "two-stream instability of a current-carrying plasma" ensues. This study comprises a thorough experimental investigation of the onset properties of this instability and an examination of its nonlinear properties. The experimental apparatus consists of a uhf TM_{010} cavity loaded along its axis with a plasma column produced by a pulsed P.I.G. reflex discharge. The electric field of the cavity serves to excite a uhf current along the plasma column which in turn can produce the two-stream instability during every half-cycle. The time scale for electrostatic interaction is much shorter than the uhf half-period. The uhf-plasma interaction is evaluated under both "normal" (without instability) and "abnormal" (with instability) conditions with the use of several diagnostic tools: (1) the cavity, (2) a Langmuir probe, (3) an 8.5-mm interferometer, (4) a uhf probe, and (5) a magnetic probe. Cavity diagnostics are based on a theoretical analysis of the cavity which considers all electron densities for collisions up to $\nu/\omega = 1$. (TSS)

Solid State Plasma

3144 (MATT-BIB-1) ANNOTATED BIBLIOGRAPHY OF ARTICLES AND BOOKS ON SOLID STATE PLASMA (Revised). (Princeton Univ., N. J. Plasma Physics Lab.). July 1966. Contract AT(30-1)-1238. 37p. Dep. CFSTI.

A listing of approximately 140 articles on all aspects of solid-state plasmas is presented. Several books are listed also. (M.O.W.)

3145 COUPLED CYCLOTRON AND SPIN WAVES IN SEMICONDUCTORS AND METALS. Lominadze, D. G.; Savchenko, M. A.; Stepanov, K. N. Zh. Eksp. Teor. Fiz., 53: 1296-1310(Oct. 1967). (In Russian).

The spectra of electromagnetic waves propagating perpendicular to a stationary magnetic field in the electron-hole plasma of magnetic semiconductors or metals are investigated. It is assumed that the electrons (holes) possess an isotropic quadratic dispersion law and an arbitrary isotropic velocity distribution function. The behavior of the frequencies of the interacting cyclotron and spin waves are determined as a function of the wave vector for arbitrary ratios between the wavelength and electron or hole Larmor radius. Simple analytic expressions of the frequencies are derived for a plasma with a small gas-kinetic pressure when the mean value of the electron (hole) velocity is much smaller than the Alfvén velocity. (auth)

Shielding

Refer also to abstracts 2314, 2507, and 3591.

3146 (ABS-THH-1029) BESTIMMUNG VON DOSISZUWACHSFAKTOREN FUER GAMMASTRAHLUNG IM ENERGIEBEREICH VON 0,5-15 MeV AN GESCHICHTETEN SCHILDEN AUS EISEN UND WASSER. (Determination of the Dose Growth Factor for Gamma Radiation in the Energy Region From 0,5 to 15 MeV in Layered Shields of Iron and Water). Vogt, H. G. (Technische Hochschule, Hanover (West Germany). Arbeitsgruppe fuer Bautechnischen Strahlenschutz). Jan. 1967. 34p. (In German). Dep.

The growth factors given by Goldstein for water were tested in a wide energy range. The growth factors measured for layered iron and water shields were compared with the results of the Criscuolo calculation program. Experiment and calculation show good agreement within the limits of error. (tr-auth)

3147 (ABS-THH-1035) BERECHNUNG VON ZUWACHSFAKTOREN UND ALBEDO-FAKTOREN MIT DEM MONTE-CARLO PROGRAMM GAMMONE. (Calculation of the Growth Factor and Albedo Factor With the Monte-Carlo Program GAMMONE). Wueneke, C. D. (Technische Hochschule, Hanover (West Germany). Argeitsgruppe fuer Bautechnischen Strahlenschutz). Jan. 1967. 32p. (In German). Dep.

The computer program GAMMONE utilizes the Monte Carlo technique in which the interaction process of γ radiation in the shield is simulated. The principle of the Monte Carlo method is outlined, and the stochastic methods used in the GAMMONE program are represented. The growth factors and albedo factors for γ radiation in layered shields were calculated, and the results are tabulated. (J.S.R.)

3148 (EUR-3636e) SABINE: A ONE DIMENSIONAL BULK SHIELDING PROGRAM. Ponti, C.; Preusch, H.; Schubart, H. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). Aug. 7, 1967. Contract 149-64-11 ISPD. 64p. Dep.

The theory and the use of a program for bulk shield design, written in Fortran IV for IBM 7090 or 360 are described. The removal diffusion model has been applied; particular attention has been paid to the treatment of the removal sources in the diffusion equations. Neutron fluxes for 26 energy groups and gamma fluxes for 7 groups are calculated in plane, cylindrical, and spherical geometry. Experimentally determined removal cross sections are used for the more important shielding materials. Gamma sources include the radiation emitted either by fission or neutron capture or inelastic neutron scattering. Three forms of region-dependent buildup factors may be used to determine the gamma fluxes: buildup factors for 6 materials have been calculated with the BIGGI 3 gamma transport program. Other quantities calculated by SABINE may be any neutron response function, gamma dose, and energy deposition. (auth)

3149 (JINR-P16-3514) OBRATNYI VYKHOD NEITRONOV IZ ZASHCHITY POD DEISTVIEM PROTONOV S ENERGIEI 660 MEV. (Back Yield of Neutrons from Shielding Bombarded by 660-MeV Protons). Kimel, L. R.; Komochkov, M. M.; Sidorin, V. P.; Sychev, B. S.; Cherevatenko, A. P. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1967. 14p. (In Russian). Dep.

Back yield of neutrons from the concrete shielding is measured ($\rho = 2.35$ g/cm^3). The beam of 660-MeV protons was directed normally to the shielding surface. The experimental data are compared with calculations. (auth)

3150 (ORNL-TM-2048) THE TRANSPORT OF 500-MeV/c MUONS IN IRON. Leimdorfer, M. (Oak Ridge National Lab., Tenn.). Nov. 7, 1967. Contract W-7405-eng-26. 13p. Dep. CFSTI.

Monte Carlo calculations of the slowing down of 500-MeV/c muons in iron cylinders are presented. The calculations include the effects of small-angle multiple-Coulomb scattering and range straggling. The results are compared with other calculations and experimental data. (auth)

3151 (SC-RR-67-419) APPLICATION OF THE METHOD OF DISCRETE ORDINATES TO PHOTON TRANSPORT CALCULATIONS. Renken, James H.; Adams, Kenneth G. (Sandia Corp., Albuquerque, N. Mex.). June 1967. Contract AT(29-1)-789. 91p. Dep. CFSTI.

A useful method for performing photon transport calculations is the method of discrete ordinates. For one-dimensional problems the formalism of this method is implemented by a computer program called DTF. This program was originally written at Los Alamos for the solution of neutron transport problems. The original version of DTF has been modified to allow practical photon transport problems to be solved conveniently. Modifications include provision for external photon sources and the capability to treat fluorescence radiation. Presented here is the information necessary to use DTF for the solution of photon transport problems. (auth)

3152 ENERGY SPECTRA OF ELECTRONS PRODUCED IN LIGHT MATERIALS BY BREMSSTRAHLUNG. Kruglov, S. P.; Lopatin, I. V. At. Energ. (USSR), 23: 156-7(1967). (In Russian).

The energy distribution of electrons generated by bremsstrah-

lung must be known in order to be able to determine the total energy incident on an irradiated material. Determination of the absolute value of the beam energy or of the absorbed dose requires calculation of the ratio, ρ, of ionization losses of electrons in the matter in the surrounding medium. The authors' earlier method was used to calculate the slowing down spectra in graphite and aluminum at $E_{\gamma max}$ values of 10, 20, and 40 MeV. It was assumed for the calculations that the electrons move in straight line trajectories in the direction of the incident beam and that the electron energy losses in the matter take place in a continuous manner. The secondary Compton effect, i.e., electron generation by scattered protons, was not taken into account. On the basis of this calculation it was possible to tabulate the number of electrons within a 1-MeV range intersecting a 1 cm^2 area for a given depth of the material for aluminum and graphite. (TTT)

3153 SPECTRAL AND ANGULAR DISTRIBUTIONS OF THE γ RADIATION OF ^{137}Cs SCATTERED IN SPHERICAL AND SLAB SHIELDS. Larichev, A. V.; Partolin, O. F.; Chistov, E. D. At. Energ. (USSR), 23: 155-6(1967). (In Russian).

The spectral and angular distributions of the γ radiation emitted by a ^{137}Cs point source and scattered in spherical and slab shaped aluminum shields were measured by means of an NaI(Tl) detector with an angular resolution of about 0.7°, using 75-mm-thick specimens. The measurements were carried out 12.5 cm from the shield, determining the angle from 0° to the limiting angle under which the spherical shield is still visible from the point of detection. By treating the spectra with an inverse matrix of the sensitivity function of the spectrometer, the energy spectrum of the scattered γ radiation was obtained. On the basis of the results it was concluded that a difference between the multiplicity factors of γ radiation attenuated by slab shaped and spherical shields is due to differences in the contribution of the scattered radiation at the point of detection. (TTT)

3154 INELASTIC SCATTERING OF KILOVOLT ELECTRONS BY SOLIDS AND LIQUIDS: DETERMINATION OF ENERGY LOSSES, CROSS SECTIONS, AND CORRELATIONS WITH OPTICAL DATA. Powell, C. J. (National Bureau of Standards, Washington, D. C.). Health Phys., 13: 1265-75 (Dec. 1967).

Some recent measurements are described. The determination of energy losses and cross sections is discussed, as well as factors influencing the accuracy of measurement. The degree of correlation between optical and electron energy loss experiments is also described. (auth)

3155 AGGREGATES FOR RADIATION SHIELDING CONCRETE. Davis, H. S. (General Electric Co., Richland, Wash.). Mater. Res. Stand., 7: 494-501(Nov. 1967).

Special and heavy aggregates used in the construction of concrete shielding structures are described, including iron ores, barite, serpentine, metallic products, and boron additives. Data on composition, physical properties, and aggregate costs are presented. A typical specification which covers practical aspects of aggregate procurement is included. (auth)

3156 USE OF INFINITE MEDIUM SPECTRA IN GAMMA-RAY HEATING CALCULATIONS. Dudley, T. E.; Mendelson, M. R.; Holden, N. E. (Knolls Atomic Power Lab., Schenectady, N. Y.). Contract W-31-109-eng-52. Nucl. Sci. Eng., 30: 328-39(1967). (KAPL-P-3189).

A reasonable physical model for the slowing down of gamma rays in infinite media is presented, and a method of numerical solution is described. Equilibrium energy spectra due to a fission source of gamma rays are shown for water, aluminum, iron, zirconium, and lead. In addition, energy spectra in aluminum, iron, and lead, due to the corresponding (n,γ) source in each metal, are presented. The use of infinite medium calculations to obtain a lower energy cutoff for a gamma heating problem is suggested. It is shown that for the case of a fission source, essentially all of the source energy is absorbed above 0.05 MeV in the materials studied, except in the case of water where approximately three percent of the energy is absorbed below 0.05 MeV. The infinite medium spectra are used to average absorption and slowing down cross sections for fuel materials and metals, and the resulting group constants are compared with similar calculations using a fission-source spectrum as a weighting function. Large differences are noted in many instances. Calculations of spatial energy deposition in simple model problems indicate that such differences in group constants can lead to local errors of significant magnitude. (auth)

3157 PRONIKAYUSHCHIE IZLUCHENIYA RADIOAKTIVNYKH ISTOCHNIKOV. (Penetrating Radiation from Radioactive Sources). Gorshkov, G. V. Second Expanded and Corrected Edition. Leningrad, Izdatel'stvo Nauka, 1967. 396p.

Basic data on the passage of gamma rays and neutrons through solids were reported. Formulas and graphs for calculation of the attenuation of radiation in different materials were given. Methods for the calculation of the dose output from radioactive sources of different form and dimension were described. Tables and graphs for the determination of the necessary thickness of shielding materials were given. (tr-auth)

Solid-State Physics

Refer also to abstracts 2124, 2369, 2397–2399, 2452, and 2608.

3158 (AED-C-29-01) BIBLIOGRAPHIEN ZUR KERNFORSCHUNG UND KERNTECHNIK. SEKTION 29: EDELGASE IN FESTKOERPERN (TRANSPORT-PHAENOMENE). (Bibliographies in Nuclear Science and Technology. Section 29: Rare Gases in Solids (Transport Phenomena)). Freyer, H. D. (comp.) (Zentralstelle fuer Atomkernenergie-Dokumentation, Frankfurt am Main (West Germany)). July 1966. 191p. (In German and English). Dep.

A bibliography of approximately 472 publications concerning the behavior of rare gases in solids and their release from solids is presented. The compilation includes papers published prior to January 1, 1961. (W.H.K.)

3159 (AWRE-O-77/67) ELECTRICAL BREAKDOWN IN VACUUM. Owen, W. D.; Davies, M. H. (Atomic Weapons Research Establishment, Aldermaston (England)). Nov. 1967. 29p. Dep. CFSTI. UK 5s. 6d.

Results of a preliminary investigation of the effect of various conditioning processes on the prebreakdown and breakdown voltage characteristics of etched Mo surfaces in high vacuum ($\sim 5 \times 10^{-9}$ torr) are reported. (auth)

3160 (BNL-11696) SYMMETRY TESTS WITH THE MOESSBAUER EFFECT. Kistner, O. C. (Brookhaven National Lab., Upton, N. Y.). Aug. 23, 1967. 36p. (CONF-670812-8). Dep. CFSTI.

From International Conference on Hyperfine Interactions, Pacific Grove, Calif.

The Moessbauer experiments designed to test parity conservation in the 14-keV transition in ^{57}Fe are reviewed. How the Moessbauer effect can be applied to the more complicated test of time reversal invariance is described and is illustrated with an experiment performed at Brookhaven which employed the 90 keV M1/E2 mixed transition in ^{99}Ru. (M.H.R.)

3161 (BNL-50053) A DATA COMPENDIUM OF LINEAR GRAPHS WITH APPLICATION TO THE HEISENBERG MODEL. Baker, George A. Jr.; Gilbert, H. E.; Eve, J.; Rushbrooke, G. S. (Brookhaven National Lab., Upton, N. Y.). Sept. 1967. 251p. Dep. CFSTI.

This report contains most of the data on free, linear, connected graphs which have been accumulated over the past three years in connection with a project which had as its aim the computation of high-temperature expansions for the field-dependent free energy of a Heisenberg-model ferromagnet, for spin-$\frac{1}{2}$ and with nearest neighbor interactions only, as far as is practicable with available computers. Only graphs with single bonds are considered, i.e., no more than one bond can connect any pair of vertices. Data which belong to the weak lattice constant system are exclusively discussed, in the terminology of Sykes et al. (J. Math. Phys., 7: 1557(1966)). (TSS)

3162 (COO-1198-486) NUCLEAR MAGNETIC RELAXATION AND ATOMIC DIFFUSION IN ALUMINUM ALLOYS. Fradin, Frank Yale (Illinois Univ., Urbana). Oct. 1967. Contract AT(11-1)-1198. 117p. Dep. CFSTI.

Measurements are presented of nuclear magnetic relaxation of ^{27}Al in pure aluminum and aluminum-base alloys containing either zinc, magnesium, silver, or germanium in concentrations between 0.1 and 5.0 atomic percent. From these measurements of spin lattice relaxation in the coordinate system rotating at the Larmor frequency of ^{27}Al, a composition-dependent activation energy for atomic diffusion and a composition-dependent local field strength at the aluminum nucleus is determined and related to both the nuclear dipole-nuclear dipole interaction and the nuclear electric quadrupole interaction. In pure aluminum the activation energy for diffusion was found to be 28.75 kcal/mole. The low activation energy in the alloys was interpreted in terms of easy atomic motion near a solute atom. An excess contribution to the Hahn echo T_2 measurements at temperatures below the melting point of aluminum, which has been previously reported, is not found in the relaxation time measurements in the rotating frame $T_{1\rho}$. This is explained in terms of a static quadrupole component of the local field at the aluminum nucleus which affects the T_2 measurements but not the $T_{1\rho}$ measurements. The observed dipolar contribution to the local field in pure aluminum is found to be about 20% larger than the theoretical value. Also, the field

dependence of the conduction electron contribution to ^{27}Al spin lattice relaxation in the rotating frame deviates from the theoretical prediction of the field dependence. These effects have been previously reported for pure aluminum in laboratory frame experiments. (auth)

3163 (COO-1434-04) IR ABSORPTION SPECTRUM OF H^+ IN RUTILE. Johnson, Owen W. (Utah Univ., Salt Lake City. Dept. of Physics). [1967]. Contract AT(11-1)-1434. 3p. (CONF-670951-1). Dep. CFSTI.

From American Institute of Physics Summer Meeting, Seattle, Wash.

It was established by diffusion doping that previously observed infrared absorption lines in rutile result from a proton or a deuteron trapped near a substitutional cation of valence 3. Three such impurity centers (involving Fe, Al, and Ga) were identified, and a fourth was detected but not identified. The exact locations of the absorption peaks at room temperature and at He temperature are tabulated. Preliminary results on H diffusion at 400 to 500°C are discussed briefly. (A.G.W.)

3164 (IFA-IS-46) MAGNETIC RESONANCE STUDIES OF THE CRYSTAL FIELD DISTORTIONS IN THE LiF:Fe^{3+} SYSTEM. Ursu, I.; Nistor, S. V.; Nicula, A.; Niculescu, V. (Academia R. P. R., Bucharest. Institutul de Fizica Atomica). 1967. 13p. Dep.

Single crystals of LiF doped with less than 0.01% Fe^{3+} ions were investigated by ESR and NMR methods in the range from 77 to 453°K. The spectra observed are explained on the basis of the hypothesis of crystal field distortion. (auth)

3165 (IFA-IS-47) SPIN-HAMILTONIAN DESCRIPTION OF THE ESR SPECTRA OF THE $^6S_{\frac{5}{2}}$ IONS IN TRIGONAL CRYSTALLINE FIELDS. Lupei, V.; Lupei, A.; Ursu, I. (Academia R. P. R. Bucharest. Institutul de Fizica Atomica). 1967. 14p. Dep.

A spin-Hamiltonian that describes ESR spectra of $^6S_{\frac{5}{2}}$ ions in trigonal crystalline fields as a function of the orientation of the crystal in the external magnetic field is given. The method of determining the spin-Hamiltonian parameters is described. (auth)

3166 (IS-1712) THERMAL CONDUCTIVITY OF MAGNESIUM STANNIDE. Martin, J. J.; Shanks, H. R.; Danielson, G. C. (Iowa State Univ. of Science and Technology, Ames). Oct. 27, 1967. 9p. (CONF-671110-1). Dep. CFSTI.

From 7th Conference on Thermal Conductivity, Gaithersburg, Md.

The thermal conductivity of the semiconductor Mg_2Sn has been determined in the temperature range 80 to 700°K from measurements of the thermal diffusivity. At low temperatures the thermal conduction is entirely lattice conduction, as shown by our earlier measurements from 4 to 300°K. At higher temperatures, however, results show that bipolar-electronic conduction (diffusion and recombination of electron–hole pairs) becomes important and actually equals the lattice conduction at 700°K. The difference between the measured thermal conductivity and the lattice thermal conductivity is in good quantitative agreement with the calculated bipolar-electronic thermal conductivity, and this agreement gives strong support to the theory of bipolar conduction in semiconductors. (auth)

3167 (NYO-2150-34) THE STARK EFFECT OF THE R CENTER IN KCl. McKinstry, Robert Gill (Cornell Univ., Ithaca, N. Y. Materials Science Center). Sept. 1967. Contract AT(30-1)-2150. 43p. Dep. CFSTI.

Thesis.

The theory of the Stark effect of the R center in KCl is presented. Experiments performed to measure the size of the splitting and to study the effects of temperature and polarization of the incident light are described. In general the results are in agreement with the current model of the R center. The matrix element $\langle E_x|x|E_x\rangle$ corresponding to the splitting was evaluated as 0.78×10^{-9} cm. (A.G.W.)

3168 (NYO-2391-64) FAR INFRARED ABSORPTION IN KI–KBr MIXED CRYSTALS. Westwig, Ralph Anton (Cornell Univ., Ithaca, N. Y. Materials Science Center). June 1967. Contract AT(30-1)-2391. 53p. Dep. CFSTI.

Thesis.

Far-infrared absorption measurements have been made on KI–KBr mixed crystals. An impurity gap mode was located in low concentration KI : Br^- at 73.8 cm^{-1}. Calculations were made using the theoretical model of Mitani and Takeno. A reduction of the impurity ion force constant was found necessary. (auth)

3169 (NYO-3822-2) RADIATION DAMAGE STUDIES USING THE CORNELL 3.0 MeV DYNAMITRON ACCELERATOR. Progress Report on First Year, January 1, 1967–December 31, 1967. Taylor, A. (Cornell Univ., Ithaca, N. Y. Dept. of Materials Science and Engineering). Contract AT(30-1)-3822. 3p. Dep. CFSTI.

Twenty radiations with 500-keV neutrons were carried out on NaCl and KBr crystals following the completion of instrumentation and temperature calibration of the cryostat. The peak spectrum of NaCl was essentially similar to previously reported results. A simplified spectrum of peaks was obtained for KBr; a comparison between γ- and neutron-induced peaks show that these crystals obey second-order annealing kinetics and are tentatively associated with annealing of the α center by Br^- interstitial migration. A number of improvements to the Dynamitron and the associated beam handling equipment were carried out. A program was initiated to study the interaction of the energetic host ions with the crystal directly. (M.H.R.)

3170 (ORNL-IIC-10(Vol.1), pp 36-58) MAGNETIC STRUCTURE STUDIES BY MOESSBAUER SPECTROSCOPY. Gonser, U. (North American Aviation, Inc., Thousand Oaks, Calif. Science Center).

The magnetic hyperfine interaction (nuclear Zeeman effect) observed by Moessbauer spectroscopy has contributed significantly to the understanding of the magnetic properties of materials usually by measuring the sign and magnitude of the internal field. Techniques have also been developed that make it possible to determine spin orientations and magnetic structures of materials in favorable cases. The following methods are discussed: Zeeman pattern from single crystals, Zeeman pattern in the presence of quadrupole interactions, effect of an external magnetic field on the Zeeman pattern, effect of lattice anisotropy on the Zeeman pattern, and the use of circularly and linearly polarized recoil-free γ rays. The discussion and examples are limited to studies involving ^{57}Fe. (auth)

3171 (ORNL-IIC-10(Vol.1), pp 59-84) THE KARYAGIN EFFECT IN MOESSBAUER SPECTROSCOPY. Travis, J. C.; Collins, R. L. (Texas Univ., Austin).

In a study made as an addition to a curve-fitting technique for extracting the electric field gradient (efg) tensor from experimental data, it was found that failure to account for Karyagin distortion in magnetically perturbed studies can lead to incorrect evaluation of the efg tensor elements. (auth)

3172 (ORNL-IIC-10(Vol.1), pp 85-100) APPLICATIONS OF MOESSBAUER SPECTROSCOPY TO STRUCTURE ANALYSIS. Spijkerman, J. J. (National Bureau of Standards, Washington, D. C.).

Moessbauer spectrum parameters of chemical shift, quadrupole splitting, magnetic hyperfine splitting, and their temperature dependence uniquely characterize the material. The interpretation of these parameters in terms of structural analyses and their relation to other spectroscopic techniques is discussed. A specific example is the determination of austenite and martensite in steel, with particular emphasis on the dynamic equilibrium exhibited by these carbon impurity states. (auth)

3173 (ORNL-IIC-10(Vol.1), pp 101-29) MOESSBAUER SPECTROSCOPY IN OXIDE SYSTEMS. Wiedersich, H. (North American Aviation, Inc., Thousand Oaks, Calif. Science Center).

Recoil-free nuclear γ-ray absorption has been used to investigate the ionic states of iron and the association of Fe^{+3} with vacancies in magnesium oxide. The dependence of the ratio Fe^{+3}/Fe^{+2} on temperature, oxygen partial pressure, and total iron concentration shows that the Fe^{+3} exists predominately as ($2Fe^{+3}$ – vacancy) complexes, which is confirmed by the presence of a well resolved quadrupole doublet of the Fe^{+3}. Divalent iron exhibits a quadrupole doublet when the concentration of iron is increased above about 6 at. %, i.e., other iron ions are present in first and second nearest-neighbor shells. The preferred substitution of Ga^{+3} for Fe^{+3} in tetrahedral coordination in $Ca_2Fe_2O_5$ has been determined from the relative absorption intensities of Fe^{57} in tetrahedral and octahedral coordination. The results can be interpreted by a free enthalpy difference of −0.23 eV for the exchange of Fe^{+3} ion in a tetrahedral site with a Ga^{+3} ion in an octahedral site taking the configurational entropy into account. Weak ferromagnetism can be distinguished from nearly compensated ferrimagnetism by the application of an external magnetic field. In weak ferromagnets the magnetizations on crystallographic equivalent sublattices are canted slightly away from ideal antiparallelism and a net moment essentially normal to the sublattice magnetizations results. As a consequence, an external magnetic field, H_{ext}, orients the sublattice magnetizations practically normal to H_{ext}. This effect has been demonstrated in α-Fe_2O_3. $CuFeO_2$ has been shown to order antiferromagnetically at ~19°K. The crystal structure is rhombohedral with the iron located on a threefold axis. Therefore, the electric field gradient is axially symmetric with the principal axis parallel to the threefold axis. The spin directions can be determined from the contri-

bution of the quadrupole interaction to the energy of the nuclear levels above and below the magnetic transition. It has been shown that the spin directions in $CuFeO_2$ are parallel to the threefold crystallographic axis. (auth)

3174 (UCRL-70715) DIFFUSION IN OXIDES: ASSESSMENT OF EXISTING DATA AND EXPERIMENTAL PROBLEMS. Birchenall, C. E. (California Univ., Livermore. Lawrence Radiation Lab.). Oct. 16, 1967. Contract W-7405-eng-48. 31p. (CONF-671024-1). Dep. CFSTI.

From NBS-ARPA Symposium on Mass Transport in Oxides, Gaithersburg, Md.

Ideal conditions for the direct measurement of diffusion coefficients in oxides are described. The need for careful measurement, whether the object is to measure intrinsic properties of pure oxides or the engineering properties of commercial materials, is emphasized. Oxides are classified as impurity-tolerant, impurity-sensitive, or borderline to judge the likelihood that intrinsic properties have been measured. A survey of several oxide structure types is given to illustrate the state of the empirical literature. (auth)

3175 (UCRL-70723) OPTICAL AND ANHARMONIC THERMAL PROPERTIES OF A DIATOMIC MOLECULAR SOLID. Jelinek, George (California Univ., Livermore. Lawrence Radiation Lab.). Oct. 11, 1967. Contract W-7495-eng-48. 6p. (CONF-671028-2). Dep. CFSTI.

From 2nd Symposium on Materials Research: Molecular Dynamics and Structure of Solids, Gaithersburg, Md.

A primitive rhombohedral equilibrium structure with large vibrational excursions from the equilibrium configurations is assumed for oxygen, nitrogen, and fluorine at low temperatures. The assumed structure involves cubic close packing of cylinders, and the effects of the harmonic, cubic, and quartic potential are considered. Thermodynamic properties calculated on this basis are in good agreement with experimental results for oxygen, nitrogen, and fluorine. Calculated results are less satisfactory for CO, and poor for chlorine, bromine, and iodine. Calculations concerning infrared spectra also show reasonable agreement with experimental results. (A.G.W.)

3176 OPTIMUM CONDITIONS FOR A MOESSBAUER TRANSMISSION EXPERIMENT. Protop, C. (Inst. of Atomic Physics, Bucharest); Nistor, C. Rev. Roum. Phys., 12: 653-60(1967).

The absorber optimum thickness in a Moessbauer transmission experiment is given. As a criterion of the optimum situation the experimental efficiency defined as the inverse of the time necessary to determine a parameter with a given standard error is considered. (auth)

3177 ORTHO-PARA CONVERSION OF H_2 AND D_2 DILUTED IN SOLID HD. Urano, K. (Univ. of Kagoshima, Japan); Motizuki, K. Solid State Commun., 5: 691-3(Sept. 1967).

The rate of ortho-para conversion of H_2 and D_2, diluted in solid HD, is calculated on the basis of magnetic dipole-dipole interaction, modulated by lattice vibrations, between the nuclear spins of the H_2 or D_2 and those of the neighboring HD's. The Debye model is assumed for the lattice vibration. The calculated conversion rate is 0.893%/hr for H_2, which is in agreement with the observed rule, and 0.482%/hr for D_2. (auth) (UK)

3178 A STUDY OF THE PERMITTIVITY DISPERSION IN SOME X-RAY IRRADIATED PVC TECHNICAL GOODS. Luca, E.; Scutaru, O.; Trifan, F.; Luca, I. Bul. Inst. Politeh. Iasi, 10: 185-92(1964). (In Rumanian).

Higher dielectric losses (as tg δ) are reported in irradiated samples at larger electron fluxes in the x-ray generating tube and higher supply voltages i.e., at an increased number and higher energy of (x-ray quanta) incident photons on the irradiated sample. Measurements were made from 100 Hz to 10 MHz and comparatively larger dielectric losses are reported at lower frequencies of the measuring current; this corresponds to an increased electron flux in the x-ray tube or to higher supply voltages whereas, at higher frequencies, the losses incurred are smaller. The dispersion zone corresponding to the maximum value assumed by tg δ is shifted towards higher frequencies at larger electron fluxes or higher supply voltages. No appreciable variations of the conservative permittivity ϵ^{-1} are reported for the investigated range. The higher dielectric losses result from the ionization of the sample atoms and molecules. (Romanian Sci. Abstr.)

3179 DEBYE-SCHERRER POWDER DIFFRACTION USING ^{55}Fe K X RAYS ON LITHIUM FLUORIDE. Toothacker, W. S.; Preuss, L. E.; Bugenis, C. K. (Edsel B. Ford Inst. for Medical Research, Detroit). Nature (London), 216: 255-6(Oct. 21, 1967).

Studies on powder and single-crystal diffraction of x rays from radioisotopes have already been reported by the authors. The x-ray source employed was cyclotron-produced ^{55}Fe on a Pt disc, and photons studied were the K_α x rays from ^{55}Mn, the stable daughter product. The activity of the source was 100mc, but this was reduced to about 19mc by self-attenuation and further reduced to about 13mc by natural decay. Experimental geometry employed was that of the conventional diffractometer. Detection was by proportional counter and sophisticated electronics. Work on metals with an ^{55}Fe source has also been reported from Russia. The present authors concluded that improved diffraction pattern recording by film exposure would be possible, and also that non-metallic powder samples might be similarly analyzed. A small Debye-Scherrer camera constructed for the purpose is described. A single LiF crystal and 200 mesh LiF powder were selected as standards for the investigation. With the single crystal a strong line due to manganese K_α on the 200 plane, and a weaker line due to manganese K_β, on the 200 plane, were observed. With the powder five diffracted lines caused by the manganese K_α were observed. These diffraction patterns, obtained without special intensification or developing techniques, show that recording of powder diffraction, by means of ordinary emulsion, is possible with an ^{55}Fe source of relatively low intensity. The times necessary for the powder diffraction patterns, however, were longer than desired. Improved resolution is also desirable. Studies are outlined with a much more intense ^{55}Fe source (500 mc); with such a source exposure times could be very much reduced or diffracted line width appreciably reduced. It seems that a zero power diffraction system of this type could be made competitive with standard techniques, especially where weight, portability, stability, and power requirements must be optimized. (UK)

3180 MOESSBAUER SPECTRA BY MEANS OF A VARIABLE-FREQUENCY ULTRASONIC SPECTROMETER. Bolef, D. I.; Mishory, J. (Washington Univ., St. Louis). Appl. Phys. Lett., 11: 321-3(Nov. 15, 1967).

The construction and method of operation of a variable-frequency ultrasonic Moessbauer spectrometer is described. Application is made to the well-known hyperfine spectrum of ^{57}Fe in a natural iron foil absorber. (auth)

3181 KNIGHT SHIFT OF ^{31}P NMR IN THE PARAMAGNETIC STATE OF URANIUM PHOSPHIDES. Friedman, F.; Grunzweig, J.; Kuznietz, M. (Israel Inst. of Tech., Haifa). Phys. Lett., 25A: 690-2(Nov. 6, 1967).

Knight shift measurements of the ^{31}P in the paramagnetic state of U_3P_4 and UP_2 are reported to be $K/\chi_M = 1.4 \pm 0.1$ mole/cm^3 for the first and 2.5 ± 0.2 mole/cm^3 for the second compound. The results are compared with those in UP and discussed. (auth)

3182 NUCLEAR MAGNETIC RESONANCE OF ^{31}P IN THE PARAMAGNETIC STATE OF UP_2. Easwaran, K. R. K.; (Tata Inst. of Fundamental Research, Bombay); Rao, V. Udaya Shankar; Vijayaraghavan, R.; Rao, U. R. K. Phys. Lett., 25A: 683-4(Nov. 6, 1967).

The ^{31}P Knight shift has been studied as a function of temperature in the paramagnetic state of the actinide intermetallic compound UP_2. The results have been interpreted on the basis of the conduction electron polarization by the localized U^{4+} moments. (auth)

3183 DE HAAS-VAN ALPHEN EFFECT OF YTTERBIUM. Tanuma, S.; Ishizawa, Y.; Nagasawa, H.; Sugawara, T. (Tokyo Univ.). Phys. Lett., 25A: 669-70(Nov. 6, 1967).

The de Haas-van Alphen effect has been observed on a ytterbium single crystal. Two kinds of oscillations are found. One has an oscillation period of 2.5 to 6.0×10^{-6}Oe^{-1} and the other has 5.5 to 7.0×10^{-7}Oe^{-1}. (auth)

3184 NEW METHOD OF SURFACE POTENTIAL MEASUREMENT. Townsend, P. D.; Kelly, J. C. (Univ. of Sussex, Eng.). Phys. Lett., 25A: 673-4(Nov. 6, 1967).

The ejection of negative ^{35}Cl and ^{37}Cl ions from sodium chloride by bombardment with low-energy electrons has been studied. Preliminary results demonstrate a method of measuring the surface potential of insulators under electron bombardment and show that it can be of considerable magnitude. (auth)

3185 PHONON DRAG EFFECTS IN TUNGSTEN BELOW 2.6°K. Long, J. R. (Univ. of Pennsylvania, Philadelphia). Phys. Lett., 25A: 677-8(Nov. 6, 1967).

The Nernst-Ettinghausen and Righi-Leduc coefficients of tungsten each show large helium temperature anomalies, which are interpreted as phonon drag effects. (auth)

3186 X-RAY TOPOGRAPHIC PICTURES OF Mo SINGLE CRYSTALS WITH THE LANG METHOD. Becker, C.; Schulze, D. (Institut fuer Metallphysik und Reinstmetalle, Dresden). Monatsber. Deut. Akad. Wiss. Berlin, 9: 92-3(1967). (In German).

The applicability of the Lang method for the x-ray topographic study of Mo crystals was studied using two different preparation methods. Mechanical separation and subsequent polishing by hand and electrochemical separation and polishing of the layers were the preparation methods used. The electrochemical preparation method was the most satisfactory. The results showed that the Lang method is suitable for the investigation of the real structure in very pure Mo single crystals. (J.S.R.)

3187 NMR RESOLUTION OF THE CHEMICAL SHIFT IN SOLIDS. Ware, D.; Mansfield, P. (Univ. of Nottingham, Eng.). Phys. Lett., 25A: 651-3(Nov. 6, 1967).

A method of approximate calculation is given, which shows that small chemical shifts, normally masked by the rigid lattice dipolar interaction, may be observed through an amplitude modulation of the envelope of a solid echo chain. (auth)

3188 ON THE PARALLELISM BETWEEN THE TEMPERATURE DEPENDENCE OF THE BRIGHTNESS OF X-RAY LUMINESCENCE AND OPTICAL FLASH IN ALKALI-METAL-HALIDE PHOSPHORS. Krongauz, V. G. Opt. Spectrosc. (USSR) (Engl. Transl.), 22: 502-3(June 1967).

Translated from Opt. Spektrosk., 22: 927-30(June 1967).

Results of a simultaneous study of the temperature dependences of the brightnesses of radioluminescence and of an optical flash stimulated by light from the absorption F band in alkali-metal-halide phosphors with different hosts (KCl, NaCl, KBr, and KI) and different activators (Ni, Cu, Pb, In, and Tl) are reported. The temperature dependence of the flash brightness was measured by illuminating a uniformly heated sample by pulses of F light. (W.D.M.)

3189 LATTICE DYNAMICS OF SOLID HELIUM AT 2.9 ^{0}K AND 125 ATM BY NEUTRON SCATTERING. Bitter, M.; Gissler, W.; Springer, T. (Kernforschungsanlage Juelich, Ger.). Phys. Status Solidi, 23: K155-8(Oct. 1, 1967).

Phonon dispersion curves of the hcp phase of solid ^{4}He were measured using inelastic scattering of slow neutrons. Time-of-flight spectra are given, and the reduced intensity vs energy transfer curves show broad phonon peaks (only one at $2\theta = 16°$). The positions of the intensity maxima are discussed. (D.L.C.)

3190 MAGNETIC ORDERING IN URANIUM MONOARSENIDE. Troc, R. (Inst. of Low Temperatures and Structural Research, Wroclaw); Murasik, A.; Zygmunt, A.; Leciejewicz, J. Phys. Status Solidi, 23: K123-8(Oct. 1, 1967).

A room-temperature powder neutron-diffraction study showed the magnetic structure of UAs to be of the first kind, the same as that of UN and UP. It consists of ferromagnetic sheets parallel to the (001) planes; the sheets are antiferromagnetically coupled. The direction of the magnetic moment is along the [001] axis, and its value for the uranium atom is $2.13 \pm 0.05\ \mu_B$. (D.L.C.)

3191 THE EFFECTS OF DEFECT DOPING ON LOW-TEMPERATURE NEUTRON-IRRADIATION DAMAGE AND RECOVERY IN ALUMINIUM AND PLATINUM. Swanson, M. L. (Chalk River Nuclear Labs., Ontario, Can.). Phys. Status Solidi, 23: 649-61(Oct. 1, 1967).

By means of residual electrical resistivity measurements, low temperature neutron-irradiation damage was investigated in Al and Pt which were doped with various defects. It was found that the damage rate of Al at 1.8°K was almost unchanged by the addition of 0.5% Mg, and furthermore, that the presence of this impurity suppressed the damage rate enhancement normally caused by deformation of high purity Al. Similar results were obtained for 1S Al, which contains 0.35% Fe + Si. These results indicate that the effect of channeling on the damage rate of Al is small. The damage rate of Pt was affected little by deformation, but was enhanced approximately 12% for samples containing $\approx 10^{-4}$ quenched-in vacancies. The stage I recovery of Pt was increased 30 to 50% by deformation or by quenched-in vacancies. The results were compared with those of other investigations. It was concluded that most of the differences between heavy and light particle irradiations were caused by the greater importance of long-range focused collision sequences in the former. (auth)

3192 GROWTH OF ZINC AND CADMIUM WHISKERS FROM THE VAPOR PHASE ON A SINGLE CRYSTAL SUBSTRATE OF THE SAME MATERIAL. Nanev, Chr.; Iwanov, D. (Bulgarian Academy of Sciences, Sofia). Phys. Status Solidi, 23: 663-73 (Oct 1, 1967).

A determination is made of the crystallographic orientation of zinc and cadmium whiskers grown on single-crystal substrates of the same substances which have well-formed faces, edges, and tips. Zinc and cadmium whiskers grown in this way in the presence of hydrogen or argon are oriented as $\langle 11\bar{2}0 \rangle$; however, zinc whiskers grown in vacuum have the orientation $\langle 11\bar{2}3 \rangle$. These are in fact the directions of the screw dislocations in the lattice. These and other results indicate that the whiskers grow preferentially via a screw dislocation mechanism. Some cases are observed in which zinc "whiskers" grow at large supersaturations without involving a surface diffusion mechanism as required by the classical theory of whisker growth. Possible causes for the appearance of whiskers on a single crystal substrate are discussed, as well as the factors which determine their orientation. (auth)

3193 CATHODOLUMINESCENCE YIELDS IN HIGHLY EXCITED CdS. Egorov, V. D.; Mueller, G. O.; Weber, H. H. (Physikalisch-Technisches Institut, Berlin). Phys. Status Solidi, 23: 703-8(Oct. 1, 1967).

An inner energy yield between 0.15 and 0.35 is obtained for the exciton emission, 489 and 493 nm, of CdS crystals at liquid nitrogen temperature under pulsed 9-keV electron excitation at a pair-production rate of about 10^{25} cm^{-3} sec^{-1} below the lasing threshold. The CdS crystals were grown without deliberate doping. Emission at other wavelengths is less than 10%; the angular dependence of the radiation is of the form expected from classical optics. According to available experimental and theoretical data the pair-production energy is equal to about three times the energy gap, hence the observed maximum energy yields correspond to a quantum yield of one. Therefore it would be expected that the transition to stimulated emission should be accompanied only by a spatial and spectral redistribution and not by an increase in efficiency. (auth)

3194 QUASI-HARMONIC CALCULATION OF LATTICE DYNAMICS FOR SODIUM. Ho, P. S.; Ruoff, A. L. (Cornell Univ., Ithaca, N. Y.). Phys. Status Solidi, 23: 489-99(Oct. 1, 1967).

A phenomenological model was applied for a quasi-harmonic calculation of the lattice dynamics for Na. The lattice potential is separated into the electrostatic energy, the ion–core exchange repulsion and the screened electron–ion potential. The ion exchange term is taken to be the Born–Meyer type potential. The model pseudopotential suggested by Heine and Abarenkov is used for the screened potential. The model parameters are determined from the elastic constants. First, dispersion curves at 90°K were calculated which agree very well with the neutron-scattering data. Then the calculation is extended to the temperature and pressure dependences of dispersion curves. The result indicates that the phonon frequencies are almost inversely proportional to the volume, a fact which is needed in the Grüneisen equation of state for solids. The martensitic transformation of Na is discussed according to the temperature dependence of the [110] shear waves along [110] direction. Some related electronic properties such as the Fermi surface distortion and the liquid metal resistivity have also been calculated as a function of pressure. (auth)

3195 INFLUENCE OF VACANCIES AND IMPURITIES ON THE DAMAGE PRODUCTION IN PLATINUM ELECTRON-IRRADIATED AT 90^{0}K. Duesing, G.; Hemmerich, H.; Meissner, D.; Schilling, W. (Kernforschungsanlage, Juelich, Ger.). Phys. Status Solidi, 23: 481-8(Oct. 1, 1967).

In platinum foils of 99.999 and 99.9% purity, different vacancy concentrations are frozen in by quenching. The foils are then irradiated with 3-MeV electrons at 90°K. The difference between the radiation damage build-up in these foils and the damage built up in annealed foils which are irradiated simultaneously is investigated up to electron doses corresponding to induced resistivities of $3 \times 10^{-7}\ \Omega$cm. It is found that (1) pre-quenching can reduce the initial damage rate by a factor of more than 20; (2) the initial damage rate of the annealed samples is independent of their purity; (3) with further irradiation, the rate of decrease of the damage rate for the annealed samples increases with the purity of the samples; (4) for large damages the dose dependence of the damage lies between $\Delta\rho \sim \varphi$ and $\Delta\rho \sim \varphi^{1/2}$. The results can easily be explained by interstitials which migrate freely at 90°K and are either annihilated by vacancies or converted into another interstitial configuration at impurities. The direct production of immobile interstitials at 90°K can be excluded. (auth)

3196 ATOMIC ARRANGEMENT IN THE HOMOGENEITY RANGE OF THE LAVES PHASES $ZrFe_2$ AND $TiFe_2$. Brueckner, W. (Zentralinstitut fuer Kernforschung, Rossendorf, Ger.); Kleinstueck, K.; Schulze, G. E. R. Phys. Status Solidi, 23: 475-80(Oct. 1, 1967).

The Laves phases $ZrFe_2$($MgCu_2$ type) and $TiFe_2$($MgZn_2$ type) have a homogeneity range of several atomic percent (mainly on the side rich in iron). An investigation is made of the modifications to this type of AB_2 lattice which result from an excess of B atoms. X-ray- and neutron-diffraction measurements show that for both $ZrFe_2$ and $TiFe_2$ the excess B atoms are associated with the sites of A-atoms. The concentration variation of the lattice constants confirms these results. (auth)

3197 DIFFUSION AND TRAPPING OF ARGON IN IRRADIATED IONIC CRYSTALS. Schmeling, P. (Kernforschungszentrum, Karlsruhe, Ger.). J. Phys. Chem. Solids, 28: 1185-96(July 1967).

The diffusion of ^{41}Ar and ^{39}Ar in single crystals of potassium chloride and potassium-doped sodium salts was measured after neutron irradiation. There appears to be a relationship between the activation energy and the energy barrier for interstitial diffusion. Low diffusion coefficients were obtained not only as a result of increased neutron dose, but also after doping with $SrCl_2$. It is assumed that trapping of rare-gas occurs and that vacancy clusters act as trapping centers. The damaged lattice partly recovers during an anneal but numerous clusters remain after prolonged heat treatment at 650°. (auth) (UK)

3198 OSCILLATORY FIELD DEPENDENCE OF THE KNIGHT SHIFT IN A MONOCRYSTAL OF TIN. Khan, S. A.; Reynolds, J. M.; Goodrich, R. G. (Louisiana State Univ., Baton Rouge). Phys. Rev., 163: 579-86(Nov. 15, 1967). (ORO-3087-25).

A detailed experimental investigation of the magnetic-field dependence of the Knight shift in a monocrystal of white tin has been performed. The measurements were made at 1.2°K and in magnetic fields ranging from 10.5 to 16.2 kG. The Knight shift is found to oscillate at the de Haas–van Alphen (dHvA) frequency, and in the range of fields investigated, exhibits two periods of 3×10^{-7} and 5.8×10^{-7} G^{-1}. The values and angular variations of these periods are in satisfactory agreement with the data on the tin Fermi surface obtained from other experiments and from a pseudopotential calculation of the band structure. The magnetic-field dependence of the amplitude of the oscillations has been investigated for both periods. The amplitude of the shorter-period component increases, and that of the longer-period component decreases, with increasing magnetic field. The decrease in amplitude of the longer-period oscillation is attributed to the effects of magnetic breakdown. The observed amplitudes are in satisfactory agreement with the assumption that the Knight-shift oscillations are due to oscillations in the ground-state wave functions of the contributing electrons rather than oscillations in the susceptibility as had been previously suggested. Measurements of the dHvA susceptibility oscillations in the same sample used for the Knight-shift measurements give further support to this viewpoint, since the field variation of the amplitude of the susceptibility oscillations is drastically different from the corresponding field dependence of the oscillatory Knight shift. (auth)

3199 ENERGY DEPENDENCE OF THE STAGE-I RECOVERY OF ALUMINUM. Chaplin, R. L.; Simpson, H. M. (Clemson Univ., S. C.). Contract AT(40-1)-3098. Phys. Rev., 163: 587-91(Nov. 15, 1967). (ORO-3098-2).

Electron irradiations have been used to determine how the atomic recoil energy changes the stage-I recovery data on aluminum samples for the near-threshold energy region. Results indicate that the recovery spectrum of aluminum is quite similar to that of copper. It is assumed that both I_C and I_{D+E} can be assigned to one crystallographic direction. These two recovery stages then have an energy dependence explained in terms of the changes of population for close pairs and distant pairs of Frenkel defects. A threshold energy is used to distinguish between I_C and I_{D+E} events. This new threshold energy is also useful for determining a characteristic energy interval that enables a comparison of aluminum with copper for existing experimental and theoretical values. (auth)

3200 ABSOLUTE INTENSITIES OF X RAYS DIFFRACTED IN ANOMALOUS TRANSMISSION THROUGH NEARLY PERFECT COPPER CRYSTALS: A COMPARISON BETWEEN THEORY AND EXPERIMENT. Baldwin, T. O. (Oak Ridge National Lab., Tenn.); Young, F. W. Jr.; Merlini, A. Contract W-7405-eng-26. Phys. Rev., 163: 591-8(Nov. 15, 1967). (ORNL-P-3177).

The absolute integrated intensities diffracted in anomalous transmission through nearly perfect crystals of copper were measured for various wavelengths and reflections by means of a double-crystal spectrometer. Great care was taken to mount and support the crystal in such a way as to minimize the effect of elastic strains. The experimental data are compared with those calculated by using: (1) the formulas of the dynamical theory of diffraction, (2) the semiclassical theory of photoelectric absorption to determine the ratio between the dynamical and the average absorption coefficient, and (3) the experimental value of the average absorption coefficient. The agreement between experiment and theory is satisfactory provided that the Debye temperature of Cu is taken equal to about 300°K. This value is in good agreement with that reported from the dependence of anomalous transmission intensities on temperature, but it is somewhat lower than the Debye temperature (315 to 317°K) deduced from data obtained by neutron inelastic scattering, Bragg x-ray measurements on powders and single crystals, and calculations from specific-heat data. An analysis is made of the various factors that can influence the experimental or calculated intensities, such as lattice defects, thickness measurements, ratio between dynamical and average absorption coefficients, contribution of the thermal diffuse and Compton scatterings to the absorption coefficient of x rays, and the choice of the Debye temperature. (auth)

3201 ISOTOPE EFFECT IN SELF-DIFFUSION IN ZINC. Peterson, N. L.; Rothman, S. J. (Argonne National Lab., Ill.). Phys. Rev., 163: 645-9(Nov. 15, 1967).

The isotope effect has been measured for self-diffusion in single crystals of zinc parallel and perpendicular to the c axis at seven temperatures in the range 289 to 418°C. A vacancy mechanism is found, with $\Delta K = 0.93$, independent of temperature within the experimental error. Dislocations are found to lower the strength of the isotope effect. Agreement with the data of Batra is fair. (auth)

3202 ELECTRICAL STUDIES OF ELECTRON-IRRADIATED n-TYPE Si: IMPURITY AND IRRADIATION-TEMPERATURE DEPENDENCE. Stein, Herman J.; Vook, Frederick L. (Sandia Lab., Albuquerque, N. Mex.). Phys. Rev., 163: 790-800(Nov. 15, 1967).

Electrical-conductivity and Hall-coefficient measurements have been used to investigate the crystal growth and irradiation-temperature dependence of the introduction and annealing of defects in electron-irradiated n-type silicon. Irradiations of 10-Ω cm, phosphorus-doped silicon with 1.7-MeV electrons were performed at controlled temperatures between 75 and 300°K, and isochronal annealing was investigated between 80 and 700°K. Both intrinsic defects and impurity-associated defects are observed. The impurity independence of annealing between 100 and 200°K suggests the annealing of intrinsic defects. The introduction rate for these intrinsic defects is independent of the irradiation temperature between 75 and 100°K. The introduction rates for the impurity-associated defects, however, exhibit an exponential dependence on the reciprocal irradiation temperature between 75 and 100°K consistent with a model based on metastable vacancy–interstitial pairs that predicts a temperature-dependent probability for vacancy–interstitial dissociation during irradiation and subsequent trapping by crystal impurities. For irradiations above 100°K, the introduction rates of impurity-associated defects are relatively independent of the irradiation temperature. Excluding the carrier-removal annealing associated with the intrinsic-defect stage, 90% of the annealing in crucible-grown silicon and ~70% of the annealing in float-zone, Dash, and Lopex silicon correlate with the annealing of the divacancy and impurity-associated defects observed in EPR and optical-absorption studies on n-type silicon. In crucible-grown silicon, the annealing temperatures of the dominant electrically active, impurity-associated defects correlate with those for the A center and other oxygen-associated defects. Measurements of carrier concentration versus temperature provide additional evidence for the dominance of the A center, which has an energy level near $E_c - 0.185$ eV, where E_c is the energy of the conduction-band minimum. A level near $E_c - 0.13$ eV also is observed in crucible-grown silicon for the oxygen-associated defects responsible for reverse annealing between 200 and 250°K. In float-zone silicon, the annealing temperatures of the dominant electrically active defects correlate with the E-center and divacancy annealing. Lopex silicon is very similar to Dash silicon, and in these materials all the annealing stages of crucible and float-zone silicon are observed. (auth)

3203 ELECTRICAL STUDIES OF NEUTRON-IRRADIATED n-TYPE Si: DEFECT STRUCTURE AND ANNEALING. Stein, Herman J. (Sandia Lab., Albuquerque, N. Mex.). Phys. Rev., 163: 801-8(Nov 15, 1967).

Hall-effect and electrical-conductivity measurements were used to investigate electrically active defects produced in n-type silicon by neutron irradiation. Samples from quartz-crucible, float-zone, Dash, and Lopex silicon were irradiated at 76 and 100°K to study the dependence of defect production and annealing on crystal growth method and irradiation temperature. Defect production by neutron irradiation is found to be relatively independent of both crystal growth method and irradiation temperature, in contrast with the marked dependence observed for electron irradiation. Illumination-sensitive defects are observed following neutron irradiation, which are not observed following electron irradiation under the same conditions. The annealing loss of the illumination-sensitive defects closely correlates with the A-center growth observed by Whan following neutron irradiation of high-oxygen-content silicon. Whan attributed the A-center growth to vacancy liberation from defect clusters. The present correlation suggests that the illumination-sensitive defects are directly associated with vacancy-liberating clusters. Evidence for neutron-produced defect clusters in silicon

has recently been obtained in electron-microscope studies by Bertolotti et al. Assuming impurity-dependent trapping of cluster-liberated vacancies, ~90% of the carrier removal measured at 76°K is due to defect clusters after 120°K annealing; after 300°K annealing, measurements at 76°K indicate that ~60% of the carrier removal in crucible-grown silicon and ~50% of the carrier removal in float-zone silicon is due to defect clusters. (auth)

3204 ORIENTATION DEPENDENCY OF A RESISTANCE INCREASE CAUSED BY ALPHA IRRADIATION. Haager, M.; Siebinger, K. Berg- Huettenmaennische Monatsh., 111: 112-16(Mar. 1966). (In German).

Single crystals of Zn with hcp lattice structure were subjected to irradiation tests at 78°K. Different specimens were used with extreme orientation. A second group of experiments was carried out with Al single crystals of 99.8% purity. These crystals have a face-centered-cubic structure. The testing temperature was again 78°K. Determination of the orientation of the single crystals was done by x-ray analysis. Irradiation time periods of 0 to 100 hr were covered in these experiments and the changes in electrical resistivity investigated as a function of irradiation time and crystal orientation. An anisotropy of the resistance change was observed as the orientation was changed. Interpretation of the changed anisotropy was done in terms of a hypothesis postulating focusing impacts, the orientation dependency of the migration energy, and the effect of channeled atoms. (Rev. Met. Lit.)

3205 INFLUENCE OF X RAYS ON SILICON AND SILICON p–n JUNCTIONS. III. FRENKEL EFFECT IN X-IRRADIATED SILICON DIODES. Krivov, M. A.; Malyanov, S. V.; Gaman, V. I. (Siberian Physical-Technical Inst., Tomsk, USSR). Izv. Vyssh. Ucheb. Zaved., Fiz., No. 6, 150-2(1967). (In Russian).

This is a continuation of earlier papers (Izv. Vyssh. Ucheb. Zaved., Fiz., No. 4, 119(1966)) reporting that x rays increase the inverse current through germanium p–n junctions. A similar effect is reported for commercial silicon diodes (D-205) exposed to x rays to 45 to 90 keV energy. Plots of the volt–ampere characteristics and of the rectification coefficient were obtained under the direct influence of the x rays and after the termination of the irradiation. The results confirm earlier theoretically derived formulas for the inverse branch of the volt–ampere characteristics and the numerical values obtained for the argument of the exponential factor in them, and it is deduced on this basis that the exposure of silicon diodes to x rays induces in them the Frenkel effect (enhancement of thermal generation of carriers in the p–n junction by a strong field). (ATD)

3206 POSSIBILITY OF STUDYING THE ULTRA-SLOW MOTION IN SOLIDS BY MAGNETIC NUCLEAR RELAXATION. Grosescu, R. (Inst. of Atomic Physics, Bucharest). Rev. Roum. Phys., 12: 615-17(1967).

The possibility of studying the ultra-slow motion in solids by nuclear magnetic relaxation is considered and it is suggested that the dipolar energy relaxation time can be directly measured and related to the ultra-slow motion. The case of metals is taken up. (W.D.M.)

3207 INTENSITY OF THE MOESSBAUER EFFECT IN CRYSTALS WITH VACANCIES AND IN SOLID SOLUTIONS IN THE CASE OF NONLOCAL VIBRATIONS. Sabitov, R. M. (Bashkir State Univ., Minsk). Izv. Vyssh. Ucheb. Zaved., Fiz., No. 6, 81-6(1967). (In Russian).

The phonon spectra obtained by S. I. Masharov (Izv. Vyssh. Ucheb. Zaved., No. 5, 39(1963)) are used to calculate the intensity of the Moessbauer line for crystals with vacancies and for solid solutions with one atom per unit cell, assuming that there are now local vibrations. The vibrations are considered in the harmonic approximation. The vacancy and impurity-atom concentrations are assumed to be small. It is shown that vacancies always decrease the absorption cross section and the Moessbauer-line intensity, and have a stronger influence on the intensity at high temperatures. In the case of solid solutions, the intensity of the Moessbauer line can increase or decrease, depending on the ratio of the masses of the component atoms and on their coupling parameters. The results can be used to determine the vacancy concentration. (ATD)

3208 EFFECT OF INFRARED ILLUMINATION ON THE LUMINESCENCE OF ZnS–Ag SINGLE CRYSTALS EXCITED BY ALPHA PARTICLES. Bezel, V. S.; Gavrilov, F. F.; Leont'ev, L. E.; Putiev, I. T. (Ural Polytechnic Inst., Sverdlovsk, USSR). Izv. Vyssh. Ucheb. Zaved., Fiz., No. 6, 149-50(1967). (In Russian).

This is a continuation of an earlier study of the duration of scintillation pulses in single-crystal ZnS:Ag (Tr. Ural. Politekh. Inst., No. 143, 36(1965)). In the present study the single crystals were illuminated at wavelengths 4 to 8 μ with an IKS-12 IR spectrometer and the luminescence was excited with 3.5- and 5-MeV α particles from ^{239}Pu, and also with ultraviolet (3660 Å). The amplitudes of the individual scintillation pulses were measured with an AI-100 pulse-height analyzer. The results show that IR illumination in the 4- to 6.5-μ range produces not only intense quenching of the scintillation pulses, but also two stimulation peaks near 6 μ (0.19 eV) and 4.5 μ (0.27 eV). The results agree well with Bethe's theory and yield additional data on the nature of the 0.15-eV trapping levels revealed by the earlier study. It is concluded that these traps, which are responsible for the scintillations, do not depend on the activator. The fact that the maximum of the stimulation at 6 μ depends on the excitation density is attributed to the filling of the shallower traps with increasing excitation. (ATD)

3209 INVESTIGATION OF THE ABSORPTION SPECTRA OF RARE EARTH ELEMENTS OF THE LANTHANUM GROUP IN THE ULTRASOFT X-RAY REGION. Zimkina, T. M.; Fomichev, V. A.; Gribovskii, S. A.; Zhukova, I. I. (Leningrad State Univ.). Izv. Akad. Nauk SSSR, Ser. Fiz., 31: 874-82(June 1967). (In Russian).

A vacuum spectrometer with a resolution of 0.2 to 0.3 eV was employed to record the x-ray absorption spectra in the 50- to 500-eV range of vacuum deposited films of La, Ce, Pr, Nd, Sm, Eu, Gd, Tm, and Yb. The measurements were undertaken to investigate the absorption due to 4d electrons in elements in which the 4f shell is partly filled. The results are presented graphically. In all the investigated elements except Tm and Yb there were observed a single strong absorption band and a number from 3 to 10 of much weaker and narrower fine structure lines on the long wavelength side of it. The positions of all the absorption peaks are tabulated. In Tm there were observed just three absorption peaks of comparable height, and in Yb, only two peaks, of which one was very weak. In all the spectra except those of Tm and Yb, the calculated position of the $N_{IV,V}$ absorption edge fell among the fine structure lines on the long wavelength side of the main absorption band. In several of the spectra there were observed three or four doublets with a constant separation of about 1 eV. A complete interpretation of the spectra will not be possible until there has been more theoretical work on the photoionization of 4d electrons in rare earth elements. (ATD)

3210 THE DEFECT STRUCTURE OF HAFNIUM NITRIDE AND THE BONDING PROBLEM. Straumanis, M. E.; Faunce, C. A. Z. Anorg. Allg. Chem., 353: 329-36(Sept. 1967). (In German).

Hafnium nitride, HfN, is of stoichiometric composition. However, lattice constant ($a_{25°}$ = 4.5118 ± 0.0001 Å) and density determinations (d_{25} = 11.696 ± 0.002, as compared with the x-ray density d_x = 13.386 g cm^{-3}) indicate the presence of vacancies (12.63%) in each of the sublattices. Hf is trivalent in the nitride. Nearly the total amount of nitrogen can be converted into NH_3. The high energy of formation of the nitride, its lattice energy, the high melting point and hardness (Pauling) show that the bonding in the nitride is mainly ionic. There is an equilibrium between the nitrogen, the N^{3-}, and the electrons in the solid nitride. Hf^{3+} is present as cations throughout. This model explains all the properties of the hafnium nitride, including the metallic ones, such as good electrical conductivity, magnetic susceptibility, metallic luster, etc. The lattice parameter calculated from the diameters of the ions is not in contradiction with the measured values, although the N anion is the larger one and the Hf^{3+} is the smaller one, in contrast to earlier assumptions. (auth)

3211 KNOWLEDGE OF THE SYSTEM Be_3N_2–Si_3N_4. IV. THE CRYSTAL STRUCTURE OF $BeSiN_2$. Eckerlin, P. Z. Anorg. Allg. Chem., 353: 225-35(Sept. 1967). (In German).

Crystals of the compound $BeSiN_2$ were made by sublimation. The structure resembles that of wurtzite; by an incomplete ordering of the Be and Si atoms a superstructure results, reducing the symmetry from hexagonal to orthorhombic and causing triplets instead of single crystals. The space group is $Pna2_1$, the parameters of the unit cell are a = 4.977, b = 5.747, c = 4.674 Å; Z = 4. Each N atom is surrounded tetrahedrally by two Be and two Si atoms. The Be atoms (as well as those of Si) occupy the centers of tetrahedrons with N atoms at the corners. These tetrahedrons form zigzag chains parallel to the a axis, chains containing Be alternating with those containing Si. This ABX_2 structure is an analog to the superstructure of sphalerite known as chalcopyrite. (auth)

3212 MAGNETIC PROPERTIES OF SCANDIUM ALLOYS. Chechernikov, V. I.; Pechennikov, A. V.; Pop, I. (Moscow State Univ.). Izv. Vyssh. Ucheb. Zaved., Fiz., No. 4, 142-4(1967). (In Russian).

The results of the investigation of the temperature dependence

of the magnetic susceptibility of the alloys Sc–Er, Sc–Ce, Sc–Al, and Sc–Y were reported. In Sc–Ce alloys this dependence has a clearly shown nonlinear form in the high-temperature range. In Sc–Er alloys the dependence has a linear form. The effective atomic magnetic moment and the paramagnetic Curie point were determined for Ce–Sc and Er–Sc. The paramagnetic Curie point underwent a very sharp change for Sc concentrations above 80%. In Sc–Al alloys, the magnetic susceptibility of alloys with high Sc content depends very slightly on the temperature. In the other alloys the dependence is very clear. In Sc–Y alloys there is a weak dependence on the temperature. (J.S.R.)

3213 QUANTUM MECHANICAL ANALYSIS OF HIGH-RESOLUTION NUCLEAR MAGNETIC RESONANCE SPECTRA. Pan, Yuh-kang. East Lansing, Mich., Michigan State Univ., 1966. 110p.

Thesis.

The quantum mechanical and algebraic procedures involved in the analysis of high-resolution nuclear magnetic resonance spectra were investigated. The formulation of the quantum mechanical problem for analysis of high-resolution nuclear magnetic resonance spectra was first discussed. Particular attention has been given to developing a convenient computer program for calculating matrix elements of the high-resolution nuclear magnetic resonance spin-coupling Hamiltonian. The derivations of general equations for the chemical shifts and spin coupling constants of a number of systems of nuclei with spin ½ in terms of the values of the experimental energy levels have been developed and presented. A computer technique for assigning the observed spectral lines to transitions within the energy-level diagram in a manner consistent with equal-spacing and intensity-sum rules has been described. It has been shown that the analysis of many complex NMR spectra can be reduced to the problem of assigning observed spectral lines to the appropriate transitions within schematic energy level diagrams, followed by direct calculation of the desired spin parameters. This computer assignment technique was then applied to examples of two-, three-, four-, and five-spin systems to illustrate the procedure. (Disser. Abstr.)

3214 INFLUENCE OF HYDROSTATIC PRESSURE UPON THE MAGNETIC TRANSITIONS IN GADOLINIUM–DYSPROSIUM ALLOYS. Milstein, Frederick. Los Angeles, Univ. of California, 1966. 102p.

Thesis.

The magnetic phase transitions in the Gd–Dy binary alloy system were experimentally investigated, and the effect of pressure upon the magnetic transitions of selected alloys was determined. The measurements are performed by correlating the magnetic phase transitions with the secondary voltage of a small toroidal transformer, the core of which is the Gd–Dy alloy itself. As the sample transforms from a nonferromagnetic to a ferromagnetic state, a large increase in permeability and hence in secondary voltage is observed. A transition from a paramagnetic state to a state in which the elementary magnetic moments are aligned in an oscillatory, nonferromagnetic manner is indicated by a sharp peak or cusp in the secondary voltage curve. In the Rudermann–Kittel theory, the Curie temperature T_c of these alloys is proportional to the quantity $(g-1)^2J(J+1)(V^2/E_F)\sum_R \Phi(2k_FR)$; g is the Lande g-factor, J is the total angular momentum quantum number, V is an intra-atomic exchange integral, E_F is the Fermi energy, and $\Phi(y) = (y\cos y - \sin y)/y^4$. The quantity $T_c/(g-1)^2J(J+1)$ was experimentally observed to increase and then decrease as a function of composition, with the peak value near 40% Gd–60%Dy, thus indicating that the quantity $(V^2/E_F)\sum_R \Phi(2k_FR)$ passes through a similar maximum. T_c for the Gd-rich alloys decreased with the application of pressure. T_c for the Dy-rich alloys appeared to increase first, and then to decrease with increasing pressure. A calculation of a 4f electron–6s electron exchange integral was performed upon a 7094 computer, and it indicated that the behavior of T_c under pressure should not be attributed to variations in V. Also, variations of the quantity E_F did not appear to explain the experimental results. It was thus concluded that the quantity $\sum_R \Phi(2k_FR)$ passes through a peak value, both as a function of pressure and of composition. The parameter which appears to be significant in determining the behavior of $\sum_R \Phi(2k_FR)$ is the c/a ratio of the crystal. (Disser. Abstr.)

3215 STUDY OF ELECTRICAL CONDUCTION IN CERIUM OXIDE. Holverson, Edwin LeRoy. Tempe, Arizona State Univ., 1965. 160p.

Thesis.

Electrical conduction in ceramic cerium oxide was studied in the temperature range from 300 to 1000°C and over a range of oxygen partial pressures from 1 to 10^{-4} atmospheres. Impurity concentrations were determined spectrographically and by controlled addition of impurities. The dependence of direct-current conductivity on temperature, oxygen partial pressure, and calcium impurity concentration was studied in detail by a four-contact method. The four-contact conductivity measurements on ceramic cerium oxide samples showed p- or n-type conduction, depending on the temperature and the oxygen partial pressure. This is interpreted as the effect of acceptor states associated with impurity atoms. Evidences of ionic conduction in calcium-doped cerium oxide were obtained. The relations between the point defects and conduction electrons at thermodynamic equilibrium were obtained by applying the law of mass action to electronic and atomic reactions taking place within the solid and between the solid and the oxygen in the ambient gas. Numerical methods were used to obtain the concentrations of defects and conduction electrons at thermodynamic equilibrium. Calculated values for the concentrations of electrons and holes were compared with experimental values of the electrical conductivity. (Disser. Abstr.)

3216 PRESSURE DEPENDENCE OF NUCLEAR SPIN RELAXATION IN ALUMINUM POWDER. Tuler, Floyd Robert. Ithaca, N. Y., Cornell Univ., 1967. 92p.

Thesis.

Nuclear spin–lattice relaxation times T_1 and spin–spin relaxation times T_2 have been measured in aluminum powder as a function of pressure to 2000 bar at a constant temperature of 450°C using nuclear magnetic resonance spin-echo techniques. Measurements were also made at constant pressure at temperatures between 430 and 494°C. A complete description is given of the apparatus used to attain the necessary high temperatures and high gas pressures. Additional line broadenings were observed, which did not allow an accurate determination of the dipolar linewidth; however, the activation volume for self-diffusion in aluminum could be estimated to be greater than 12 cm^3/mole. Two mechanisms are believed to account for the additional line broadening: a temperature- and pressure-independent mechanism representing quadrupole coupling to strain fields of dislocations and a temperature- and pressure-dependent mechanism representing either local magnetic fields or quadrupole coupling to strain fields of impurities. Analysis of the temperature- and pressure-dependent additional line broadening yields approximately an activation energy of 15.5 kcal/mole and an activation volume of 27.0 cm^3/mole for the mechanism associated with impurities. (Disser. Abstr.)

3217 MOESSBAUER EFFECT STUDY OF THE MAGNETIC STRUCTURE OF SINGLE-CRYSTAL ERBIUM. Reese, Richard Allan. Ames, Iowa, Iowa State Univ. of Science and Tech., 1967. 86p.

Thesis.

The rare earth metal erbium exists in three magnetically ordered states below its Néel temperature of 85°K. The magnetic structure of these three states was studied using the Mössbauer effect with single-crystal absorbers. The ratios of the areas under the hyperfine absorption maxima are related to the angle between the direction of magnetization and the gamma-ray propagation direction. By studying these area ratios it was possible to obtain information about the magnetic structures. In the low-temperature region (below 20°K), analysis of the data, on the assumption of a cone structure, yields a value of 26 ± 3° for the semi-apex angle of the cone. In the intermediate temperature region (20 to 52°K), five-line Mössbauer absorption spectra were obtained, which were qualitatively similar to those obtained in the low-temperature phase. In the high-temperature phase (52 to 80°K), a two-line Mössbauer spectrum was obtained when the c-axis of the crystal was parallel to the gamma beam. For the heavy rare earths the hyperfine field is principally due to the polarization of the 4f electrons, so that the hyperfine field is proportional to the magnetic moment of the ion. The observation of a well-resolved spectrum indicates that the range of values for the phases. Results are compared with the neutron-diffraction results of Cable et al., [Phys. Rev., 140A: 1896 (1965)]. The temperature dependence of the magnetic hyperfine field and the electric quadrupole interaction were measured between 4.2 and 80°K. Although the probable errors are quite large, a T^2 temperature dependence appears to fit the data better then a $T^{3/2}$ or a Brillouin function dependence. The value of the magnetic hyperfine field extrapolated to 0°K is 7.71 ± 0.15×10^6 Oe. The quadrupole splitting decreases with temperature to about 50°K where it can no longer be separated from the experimental noise. (TSS) (Disser. Abstr.)

3218 RADIOSPEKTROSKOPIYA TVERDOGO TELA. (Radiospectroscopy of Solids). Al'tshuler, S. A. (ed.). Moscow, Atomizdat, 1967. 452p.

This compilation includes 135 monographs on the radiospectroscopy of solids. The book is divided into four sections: general questions, nuclear magnetic resonance, nuclear quadrupole resonance, and electron paramagnetic resonance. In the section on nu-

clear magnetic resonance, the topics discussed are experimental apparatus and methods, studies of structure and internal mobility in crystals, nuclear magnetic resonance in polymers, studies of zeolites, electron–nuclear interactions, relaxation phenomena in NMR, and nuclear magnetic resonance in ferromagnets. In the section on nuclear quadrupole resonance, the topics discussed are experimental apparatus and methods and investigations of crystals and polymers. In the section on electron paramagnetic resonance, the topics discussed are theoretical questions, experimental apparatus and methods, investigation of crystals, relaxation phenomena, use of EPR, radiation effects, and investigation of high-molecular compounds and polymers. (J.S.R.)

3219 EFFECT OF HIGH PRESSURE ON THE PROPERTIES OF SOME METALS. Raimondi, Donald Louis. Berkeley, Calif., Univ. of California, 1966. 105p.

Thesis.

An equation of state for aluminum to the Debye approximation has been obtained from the determination of the Debye temperature, Θ, as a function of pressure from 0 to 135 kbars. The variation was determined by use of the Bloch–Grüneisen equation in fitting experimental resistance-temperature data at various pressures. The zero pressure thermodynamic properties of aluminum calculated from the equation of state agree quite well with the corresponding observed quantities. It is found that the Grüneisen ratio, $-d\ln\Theta/d\ln V$, is a linear function of volume at pressures above 40 kbars. An analytical expression which approximates the observed volume dependence of the Debye temperature is given by, $\Theta = 395\ e^{-1.78\Delta V/V_0}$. The effect of high pressure on the Moessbauer spectrum of ^{57}Fe in iron was studied to a pressure of 140 kbars with particular interest in the transition of α-iron to the hcp phase. Because of the low intensity of the observed Moessbauer lines, the results are qualitative. A current-pulse technique was applied to the iron at pressures of 120 kbars and above, but a sharp transition was not observed. It was found that after decompression from 140 kbars to 120 kbars, the transformation of hcp-iron to α-iron could be followed kinetically by measuring the decrease in intensity of a strong single line characteristic of the hcp-iron and correspondingly, the increase in the intensity of the normal six line spectrum of α-iron. The estimated rate constant for the transformation of hcp-iron to α-iron at 120 kbars and 298°K is 0.012 hr^{-1}. In order to better understand the interaction of the ferromagnetic host with an impurity atom in a dilute alloy, the Moessbauer spectrum of ^{57}Fe in nickel metal was studied to 80 kbars. A peak in the internal field at the ^{57}Fe nucleus was observed at 10 kbars, followed by a slow decrease up to 80 kbars. The initial increase of the internal field with pressure is given by $d\ln H/dP = 10.2 \times 10^{-4}$ $kbar^{-1}$. The change in the isomer shift over the entire pressure range is given by $d(IS)/dP = -4.15 \times 10^{-5}$ cm $sec^{-1}kbar^{-1}$. These results are discussed as they relate to other pressure studies on the properties of pure nickel and iron. (Disser. Abstr.)

3220 EFFECTS OF SPIN FLUCTUATIONS ON THE PROPERTIES OF TRANSITION METALS. Berk, Norman Fredric. Philadelphia, Univ. of Pennsylvania, 1966. 139p.

Thesis.

The observed behaviors of the superconducting transition temperature, low temperature electronic specific heat coefficient, and magnetic susceptibility in nearly ferromagnetic transition metals are discussed in terms of a many-body theory which accounts for the effects of spin fluctuations induced by the strong exchange interactions. Mathematically the spin fluctuations are characterized by the electron-hole t-matrix, which is treated within a simplified one-band model that allows electrons to interact via a highly screened, short ranged Coulomb potential. Correlations important in narrow d-band metals are accounted for phenomenologically by assuming that the irreducible electron-hole interaction is well represented by an effectively short ranged interaction whose matrix element is constant. Within the model, the normal state properties of interest are studied by including the frequency- and wave-vector dependent t-matrix in a low-temperature calculation of the one-electron self-energy by means of the Green's function technique. The effect of spin fluctuations on the superconducting transition temperature is studied by including the t-matrix in the irreducible singlet-state pairing interaction and numerically solving the resulting linearized gap equation. The phonons are treated in an Einstein model, and the Nambu scheme is employed. The details of the analytic and numerical analysis are presented. The results show that spin fluctuations contribute a repulsive term to the pairing interaction, which diverges at the ferromagnetic instability and is large enough to totally suppress superconductivity in metals, like Pd, whose susceptibility is strongly exchange enhanced. In addition, spin fluctuations lead to a giant quasi-particle effective mass enhancement, which also diverges at the ferromagnetic instability. From a consistent analysis of data, the mass enhancement in Pd is found to be a factor of 8, indicating that the d-band density of states in Pd is much smaller than generally assumed, and the exchange enhancement of the susceptibility of Pd is found to be a factor of 50. The formulas derived and numerical results are combined to analyze the data for the Rh–Pd–Ag series. The major results are that the observed variation of the specific heat coefficient is due primarily to the variation of the spin fluctuation mass ennancement, the d-band density of states being slowly varying near Pd and roughly 8 times smaller than the value usually implied from the specific heat. The effective exchange interaction in the series is found to be correspondingly high being about 4 eV near Pd. Also, a new criterion for superconductivity is presented which appears to be in good agreement with observations. Experimental evidence for the predicted effects is analyzed, and the extension of the theory and results to other systems, for example, liquid ^3He is discussed. (Disser. Abstr.)

Theoretical Physics

3221 (ORNL-TM-2008) STUDY OF THE THREE-BODY PROBLEM IN QUANTUM MECHANICS. Marable, J. H. (Oak Ridge National Lab., Tenn.). Nov. 1967. Contract W-7405-eng-26. 137p. Dep. CFSTI.

Thesis. Submitted to Univ. of Tennessee, Knoxville.

The purpose of the study was to develop general methods for the calculation of quantum-mechanical three-body problems. In particular, methods are needed to calculate wave functions of bound systems and scattering systems in which the form of the potential is as general as possible. The method developed has been shown to give good results for the bound state of the helium atom. Particular systems for which this method appears to be especially useful are the scattering of nucleons by deuterons, direct reactions involving deuterons, and nuclear reactions involving three-body final states. (W.D.M.)

3222 (TH-213) THINGS, STRUCTURES AND PHENOMENA IN QUANTUM PHYSICS. d'Espagnat, Bernard (Paris Univ., Orsay (France). Laboratoire de Physique Theorique et Hautes Energies). [1966]. 10p. (CONF-670826-1). Dep.

From 3rd International Congress for Logics, Methodology, and Philosophy of Science, Amsterdam, Netherlands.

A very theoretical discussion is given on the interpretation of the general rules of conventional quantum mechanics. (W.D.M.)

3223 (UCD-CNL-82) DENSITY-MATRIX VARIATIONAL PRINCIPLES AT FINITE TEMPERATURES. Garrod, Claude (California Univ., Davis. Crocker Nuclear Lab.). Aug. 14, 1967. Contract AT(11-1)-Gen-10. 9p. (CONF-670828-1). Dep. CFSTI.

From Density Matrix Conference, Kingston, Canada.

Until very recently work done on variational principles involving reduced density matrices has been confined almost entirely to principles involving the ground-state properties of quantum systems. During the past year Kijewski and Percus have attacked the problem of extending the density matrix variational methods to systems at non-zero temperature by using the free-energy minimum principle. The work presented in this paper is a somewhat different approach to the same problem. (W.D.M.)

3224 (UCD-CNL-83) PROPERTIES OF THE 2-MATRIX DUE TO THE INTEGER CHARACTER OF OCCUPATION NUMBERS. Garrod, Claude (California Univ., Davis. Crocker Nuclear Lab.). Aug. 1967. Contract AT(11-1)-Gen-10. 6p. (CONF-670828-2). Dep. CFSTI.

From Density Matrix Conference, Kingston, Canada.

The simple fact that the number of particles in any quantum state can only be an integer has nontrivial consequences for the properties of reduced density matrices. In this paper some of the simpler inequalities involving density-matrix elements which can be traced to the discreteness of the particles are investigated. (TSS)

3225 (UCD-CNL-84) VARIATIONAL CALCULATIONS WITH DENSITY MATRICES. Garrod, Claude (California Univ., Davis. Crocker Nuclear Lab. Aspen Inst. for Humanistic Studies, Colo.). Aug. 1, 1967. Contrct AT(11-1)-Gen-10. 5p. (CONF-670828-3). Dep. CFSTI.

From Density Matrix Conference, Kingston, Canada.

A brief review is given of the variational method developed by Percus and Garrod (J. Math. Phys., 5: 1756(1964) and Phys. Fluids, 9: 1764(1966)). Some applications of the method which are presently in progress are described. (TSS)

3226 SUM RULES IN QUANTUM MECHANICS. Ferreira, E. M. (International Center for Theoretical Physics, Trieste, Italy); Sesma, J. Notas Fis., Cent. Brasil. Pesqui. Fis., 12: No. 20, 341-66(1967).

The sum rules usually derived for the squares of the matrix elements of the co-ordinate operator between eigenstates of a Schrödinger Hamiltonian are here extended to the matrix elements of more general operators taken between the states of any complete set of states. For that purpose extensive use is made of the closure relation for the set of eigenstates of a hermitian operator. Several applications of the sum rules obtained are made. (auth)

3227 OPERATOR EQUATIONS IN PERTURBATION THEORY. Arthurs, A. M.; Robinson, P. D. (Univ. of York, Eng.). Proc. Roy. Soc. (London), Ser. A 301: 507-12(Nov. 7, 1967).

Quantum mechanical perturbation theory is discussed in terms of solutions W of commutator equations of the type [h,W] = A. The operators W lead to perturbation corrections for any eigenstate of the unperturbed system. The theory is illustrated by considering the linear harmonic oscillator perturbed by the Nth power of the displacement. (auth) (UK)

3228 TRANSFER OF CHARGED PARTICLES INTO MAGNETIC DIPOLE FIELD UNDER THE ACTION OF DISTURBING ELECTROMAGNETIC PULSES. Ershovich, A. I.; Skuridin, G. A.; Chesalin, L. S.; Shalimov, V. P. Kosm. Issled., 5: 792-4(Sept.-Oct. 1967). (In Russian).

Effects of various electromagnetic pulses on the motion of nonrelativistic charged particles in a vacuum in a dipole magnetic field were studied. Equations of motion are integrated numerically for separate particles (in a drift approximation). The mean longitudinal and mean-square shifts obtained are integrated in Fokker–Planck equations describing particle transfer. The steady-state solutions obtained are correlated with experimental data on the external proton belt. (tr-auth)

3229 NEW PROOF OF A THEOREM BY SHE AND HEFFNER ON COHERENT STATES. Bausch, R.; Schloegl, F.; Stahl, A. (Technische Hochschule, Aachen). Phys. Lett., 25A: 647-8(Nov. 6, 1967).

It is shown how coherent states may be constructed from a condition of minimum uncertainty. (auth)

3230 A NOTE ON TIME DEVELOPMENT OF COHERENT STATES. Mista, L. (Palacky Univ., Olomouc, Czech.). Phys. Lett., 25A: 646-7(Nov. 6, 1967).

The problem of the time development of coherent states is considered for a Hamiltonian for a one-mode electromagnetic field of the type $\hat{H} = \omega(t)\,\hat{a}^+\hat{a} + \lambda^*(t)\hat{a} + \lambda(t)\hat{a}^+ + \mu(t)\hat{a}^+\hat{a}^+ + \mu^*(t)\hat{a}\hat{a} + \kappa(t)\hat{a}^+\hat{a}^+\hat{a} + \kappa^*(t)\hat{a}^+\hat{a}a$. (auth)

3231 ONE CASE OF HAMILTON–JACOBI EQUATION INTEGRABILITY. Glikman, L. G.; Yakushev, E. M. Porosh. Met., Akad. Nauk Ukr. SSR, 31: 937(Sept.-Oct. 1967). (In Russian).

The Hamilton–Jacobi equation $\partial S/\partial t + (\partial S/\partial r)^2 + F = 0$ (where S is the acting function and F is the assigned function for r at t variables) was resolved as $S = S_0 + S_1$, $S_0 = X_0(x)T_0(t)$, and $S_1 = X_1(x) + T_1(t)$. The equations can be applied for resolving the motion of nonrelativistic charged particles in a certain class of alternating electromagnetic fields. (R.V.J.)

3232 A NEW ASPECT OF THE CALCULATION OF THE BOUNDED ENERGY SPECTRUM AND OF THE EIGENFUNCTIONS IN THE SCHROEDINGER EQUATION. Almstrom, H. (Royal Inst. of Tech., Stockholm). Nuovo Cim. (10), 51A: 1151-3(Oct. 21, 1967).

A method is presented for calculating the bounded energy spectrum and eigenfunctions in the Schroedinger equation in which a wave test function is chosen to give eigenfunctions corresponding to the lowest eigenvalues. (L.B.S.)

3233 QUANTUM STATISTICS OF COUPLED OSCILLATOR SYSTEMS. Mollow, B. R. (Brandeis Univ., Waltham, Mass.). Phys. Rev., 162: 1256-73(Oct. 25, 1967).

The statistical properties of systems of coupled quantum-mechanical harmonic oscillators are analyzed. The Hamiltonian for the system is assumed to be an inhomogeneous quadratic form in the creation and annihilation operators, and is allowed to have an explicit time dependence. The relationship to classical theory is emphasized by expressing pure states in terms of the coherent-state vectors, and density operators by means of the P representation and an analogous representation involving the Wigner function. The state which evolves from an initially coherent state of the system is found, and equations governing the time evolution of the Wigner function and the weight function for the P representation are derived, in differential and integral form, for arbitrary initial states of the system. The results remain valid for couplings which do not preserve the vacuum state, and for cases in which the time dependence of the coupling parameters gives rise to large-scale amplification of the initial field intensities. The analysis is performed by first treating general linear inhomogeneous canonical transformations on the oscillator variables, and then specializing to the case in which these transformations represent the solutions for the Heisenberg operators in terms of their initial values. The results are illustrated within the context of a model of parametric amplification. (auth)

3234 PERTURBATION-VARIATIONAL APPROACH TO THE CALCULATION OF VARIATIONAL WAVE FUNCTIONS. I. THEORY. Silverman, Jeremiah N.; van Leuven, Jon C. (General Dynamics, Fort Worth, Tex.). Phys. Rev., 162: 1175-94(Oct. 25, 1967).

Certain aspects of Rayleigh–Schrödinger (RS) perturbation theory and of the variational principle are combined in a new perturbationally oriented variational approach for obtaining approximate solutions to Schrödinger's time-independent equation. This perturbational-variational (PV) procedure is applicable for all perturbed Hamiltonian operators which can be expanded as $H(\lambda) = \Sigma H_i\lambda^i$, where λ is an external parameter governing the strength of the perturbing terms; in particular, the theory is developed here for the important special form, $H = H_0 + H_1\lambda$. It is shown how the application of the PV procedure to an arbitrary analytic approximate wave function yields the variational parameters embedded in the wave function, the wave function itself, the corresponding approximate energy, and other expectation values, all in the form of energetically optimized PV expansions in powers of λ to any desired order. A variational wave-operator formalism is introduced to deal with the multivariant expansions required to form the PV expansions. The remainder theorem and the variational Hellmann–Feynman theorem are derived and their role in the PV methodology is discussed. The principal advantages of the new method are: (1) unlike RS perturbation theory, there is no requirement that the exact solution of a simpler unperturbed system be known; (2) the explicit λ dependence of the optimum quantities is analytically derived; (3) the numerical aspects of a given variational problem are simplified because the variational equations generated by the PV procedure are almost completely linearized in the variational parameters; and (4) the PV expansions form a natural framework for the systematic classification and evaluation of all perturbed variational wave functions in respect to their quality. The PV classification scheme, previously presented in bare outline, is rigorously derived. The insight obtained from PV theory is further illustrated by the derivation and application of the variational integral Hellmann–Feynman theorem, the virial theorem, and a theorem relating to the expectation value of the unperturbed potential. The a priori PV classification of perturbed variational wave functions is extended to the perturbed variational parameters embedded in the wave functions; it is shown that the anomalous PV expansions of some open-shell parameters and orbitals can be simply explained in terms of PV theory. (auth)

PHYSICS (HIGH ENERGY)

Particle Interactions and Properties (Experimental)

3235 PERSPECTIVE IN HIGH ENERGY PHYSICS. Jacob, M. Bull. Inform. Sci. Tech. (Paris), No. 117, 77-87(July-Aug. 1967). (In French).

Carrying forward present research in high energy physics requires complex and costly equipment. Moreover it is already necessary to start building the accelerators which will be able, within the coming decade, to push further the work carried on the present machines, the technical possibilities of which already restrict too much our field of investigation. A survey is presented of high energy physics as it now stands, the reasons which make it compelling for us to build bigger machines, and so justify the important program which this implies both on the European and French level. (auth)

Electromagnetic

Refer also to abstracts 2846–2848.

3236 (INR-792/VI/PH) FRAGMENTATIONS OF COSMIC RAY NUCLEI WITHOUT PARTICLE PRODUCTION AT THE ENERGY RANGE 10 TO 1000 GeV/nucl. Rybicki, Krzysztof (Institute of Nuclear Research, Warsaw (Poland)). 1967. 8p. Dep.

The 34 interactions in which primary nuclei of cosmic radiation break up without visible particle production are described. This process was observed for $Z_{inc} = 2 - 9$ nuclei at energies ranging from 10 GeV/nucl to some TeV/nucl. In majority of cases there are no tracks of low-energy particles coming from the target nucleus. These events are well interpreted in terms of photodisintegration of incident nucleus by photon from the Coulomb field of heavy emulsion nucleus (Ag, Br). The remaining events correspond to collisions with light emulsion nuclei (H, C, N, O) and are connected with strong interactions. (auth)

3237 OBSERVATION OF EXTREMELY HIGH ENERGY NUCLEAR INTERACTIONS WITH EMULSION CHAMBER. Akashi, M. (Hirosaki Univ., Japan); Watanabe, Z.; Nishikawa, K.; (and others). Notas Fis., Cent. Brasil. Pesqui. Fis., 13: 73-116(1967).

Experimental results obtained from emulsion chambers exposed at Mt. Chacaltaya (5,200 m), Bolivia and Mt. Norikura (2,800 m), Japan are reported. The chamber consists of three parts—an upper chamber, the producing layer, and a lower chamber. Results are reported on flux measurements of γ rays and electrons, transverse momentum distribution and fire ball analysis of C-jets, and atmospheric interactions of $E_\gamma \geq 10$ TeV. (L.B.S.)

3238 EXPERIMENTAL TEST OF ELECTRON-SCATTERING SUM RULES FOR CARBON. Feissler, W. L.; Pipkin, F. M.; Stanfield, K. C. (Harvard Univ., Cambridge, Mass.). Contract AT(30-1)-2752. Phys. Rev. Lett., 19: 1202-5(Nov. 13, 1967).

The cross section for scattering of electrons off carbon was measured at laboratory angles of 3.3, 6, and 12° for incident energies of 1 to 5 GeV. The measured cross sections are in good agreement with the sum rules describing this process. (auth)

3239 PHOTOPRODUCTION OF π^+ MESONS AT 3.4 AND 5.0 GeV. Joseph, P. M.; Hicks, N.; Litt, L.; Pipkin, F. M.; Russell, J. J. (Harvard Univ., Cambridge, Mass.) Contract AT(30-1)-2752. Phys. Rev. Lett., 19: 1206-9(Nov. 13, 1967).

Measurements of the photoproduction from hydrogen of single π^+ mesons at gamma-ray energies of 3.4 and 5.0 BeV and at laboratory angles of 5.1, 7.1, 9.9, and 15.1° are reported. The s dependence at fixed t is derived for momentum transfers of −0.20, −0.37, and −0.70 BeV^2. The pion data are compared with a Reggeized one-pion-exchange model. (auth)

3240 COMPARISON OF ELASTIC POSITRON–PROTON AND ELECTRON–PROTON SCATTERING CROSS SECTIONS. Cassiday, G.; DeWire, J.; Fischer, H.; Ito, A.; Loh, E.; Rutherfoord, J. (Cornell Univ., Ithaca, N. Y.). Phys. Rev. Lett., 19: 1191-2 (Nov. 13, 1967).

The ratio of positron–proton and electron–proton elastic scattering differential cross sections was measured at 1700-MeV incident beam energy. The detection apparatus consisted of thin-foil spark chambers, scintillation counters, and total-absorption lead–glass Cherenkov counters. The values of the ratio thus obtained are shown. (J.F.P.)

3241 ANGULAR DISTRIBUTION OF ELECTRON PAIRS PRODUCED BY POLARIZED PHOTONS AT THE FRASCATI ELECTROSYNCHROTRON. Barbiellini, C. (CNEN, Frascati, Italy); Letardi, T.; Visentin, R.; Grianti, F. Nuovo Cim. (10), 51A: 1124-32(Oct. 21, 1967).

In order to obtain detailed knowledge on the possibility of electron pair production to be used as a proper polarimeter a measurement of 150-MeV photon polarization was performed by measuring the angular distribution of the electron pair. Details are given of the experimental set-up, which consists of two wide-gap spark chambers placed beside the Frascati pair spectrometer. (L.B.S.)

3242 LATERAL AND ANGULAR STRUCTURE OF ELECTROMAGNETIC CASCADES. Jones, William Vernon. Baton Rouge, Louisiana State Univ., 1967. 120p.

Thesis.

Simultaneous measurements of the radial position and angular orientation of electrons in ten high-energy electromagnetic cascades which were initiated by single γ-rays were made. Six cascades having energies in the range 845–2000 BeV which were developed in a large pure emulsion stack were measured up to the radial distance 2.1×10^{-2} r.l. from the cascade axis. Four cascades which were developed in a lead-emulsion sandwich stack were measured up to the radial distance 7.4×10^{-2} r.l., and these cascades had energies in the range 178–720 BeV. Numerical calculations of the angular distributions from cascade theory were performed within approximation B and within the core approximation. A method was presented for utilizing the energy determination from the angular distribution to establish the correct effective radiation length of a heavy sandwich stack. The integral radial and angular distributions which were obtained experimentally were compared with the predictions of cascade theory under approximation B and the core approximation. No clear deviation of the experimental results from the radial core approximation was found over the range of energies and distances which were measured, but approximation B was found to underestimate the total number of particles. It was shown that the radial range must extend up to approximately 7×10^{-2} r.l. for the cascades measured in the sandwich stack in order to permit the measurement of all particles having angles even as small as those in the range up to 4–5°. The radial distance 2.1×10^{-2} r.l. measured for the cascades in the pure emulsion stack did not allow the measurement of all particles even at 1–2°. The energy determination using only small angles from the angular distribution of particles in the sandwich stack agreed with the standard method of using the radial distribution. Therefore, it was concluded that the cascade theory is internally consistent under the core approximation and that the "wavelength" of the particular sandwich stack that was used was sufficiently small so that the arrangement could be considered to be a homogeneous mixture of lead and emulsion. (Disser. Abstr.)

3243 THE PHOTOPRODUCTION OF K^+ MESONS FROM HYDROGEN NEAR THRESHOLD. Bradbury, James Norris. Stanford, Calif., Stanford Univ., 1966. 98p.

Thesis.

The near threshold photoproduction of the $K^+\Lambda$ system from hydrogen was studied using a bremsstrahlung beam. Measurements of the angular distribution of the reaction cross section were made in the cms angular interval from 50 to 130° at a laboratory photon energy of 940 MeV. Two cross sections at photon energy 975 MeV were also measured to check agreement with data obtained elsewhere. The K mesons were selected with a magnetic analyzer and counter telescope system, and both range and time-of-flight criteria were utilized to aid in the rejection of pions and protons. The final K meson identification was made on the basis of the correlated pulse heights in the counter telescope. The observed angular distribution at photon energy 940 MeV is isotropic implying, in conjunction with other data, S-wave production. The results are compared to the predictions of a particular phenomenological resonance model for the reaction. (Disser. Abstr.)

3244 ELECTROPRODUCTION OF π-MESONS FROM HYDROGEN. Berezin, Stephen Philip. Stanford, Calif., Stanford Univ., 1966. 167p.

Thesis.

The electroproduction of π-mesons ($e^-p \rightarrow e^-n\pi^+$) and the electroproduction of π-meson pairs ($e^-p \rightarrow e^-p\pi^+\pi^-$) were investigated utilizing the electron linear accelerator. The experiment was performed at two values of the initial electron energy (700 and 900 MeV) and three values of the π-meson production angle (40, 60, 90°). The π-mesons resulting from the interaction were momentum-analyzed by the 72-in. radius magnetic spectrometer and were de-

tected by a combination of a 2-counter, plastic scintillation telescope and 16 in. of NaI(Tl) arranged into 4 optically separated counters. Pulse-height analysis of counts from the NaI(Tl) counter system permitted the determination of the energy of the detected particle. Cross sections for the single-π^+-meson production are analyzed in terms of the virtual photon spectrum associated with the scattered electron and are compared to the latest photoproduction data. Cross sections for the π-meson pair production reaction can be analyzed in terms of its available phase space. It is shown that the N^{*2+} isobar dominates the threshold behavior for this case. (Disser. Abstr.)

3245 UPPER LIMITS ON NEUTRAL ASSOCIATED PHOTOPRODUCTION CROSS SECTIONS. Coyne, Donald Gerald. Pasadena, Calif., California Inst. of Tech., 1967. 136p.

Thesis.

A search for events of the type $\gamma + n \rightarrow K^0 + \Lambda^0$ or $\gamma + n \rightarrow K^0 + \Sigma^0$ was made. Photon energies up to 1530 MeV were available. The technique used was to observe the region near the interaction point using a heavy liquid bubble chamber, with the liquid surrounding a central tube containing deuterium gas. About 14,000 pictures were multiply scanned and analyzed by techniques developed especially for these reactions. The most probable conclusion is that no events of the above types were seen. The meaning of this result in terms of limits on the average cross sections for those interactions is given, and the significance of the result with respect to previously published theories and experiments is discussed. (Disser. Abstr.)

3246 π^+ PHOTOPRODUCTION AT ANGLES FROM 50° to 165° C.M. AND ENERGIES FROM 500 TO 1350 MeV. Thiessen, Henry A. Pasadena, Calif., California Inst. of Tech., 1967. 172p.

Thesis

The cross section for the reaction $\gamma + p \rightarrow \pi^+ + n$ was measured. The π^+ was detected in a multi-channel magnetic spectrometer, and the data were recorded in the memory of a pulse-height analyzer. The results are presented in the form of energy distributions at 12 fixed laboratory angles from 34 to 155°. There are 378 cross section measurements reported with photon energies between 500 and 1350 MeV. No detailed fitting of the entire angular range was attempted; however, a narrow bump in the cross section at 180° is explained as the effect of a cusp at the eta meson threshold. (Disser. Abstr.)

3247 PHOTOPRODUCTION OFCHARGED PION PAIRS AND $N^*(1238)^{++}$ IN HYDROGEN FROM 0.9 TO 1.3 GeV. Hauser, Michael George. Pasadena, Calif., California Inst. of Tech., 1967. 217p.

Thesis.

The momentum spectrum and angular distribution of negative pions produced in the reaction $\gamma + p \rightarrow \pi^- + \pi^+ + p$ were measured at eight incident photon energies from 0.9 to 1.3 GeV. The reaction was produced in a liquid hydrogen target illuminated by a bremsstrahlung beam. Negative pions were detected and momentum analyzed with a magnetic spectrometer employing a combination of scintillation counters and Cherenkov counters. The incident photon energy was fixed by using the technique of bremsstrahlung subtraction. The cross section for the pseudo-two-body reaction $\gamma + p \rightarrow \pi^- + N^*(1238)^{++}$ was obtained by fitting the π^- momentum spectrum at each angle and energy with a linear combination of a resonance term and a three-body phase space term. The angular distribution of the π^- in N^* production is in good qualitative and fair quantitative agreement with predictions of the Drell (OPE) model. Gauge invariant models are in poorer agreement with the data. The total cross section for pion pair production decreases smoothly from 78.9 ± 2.9 μb at .93 GeV to 59.1 ± 5.2 μb at 1.29 GeV, where as the N^* part of the cross section decreases from 45.0 ± 2.4 μb to 18.2 ± 3.5 μb over the same range. A slight shoulder in each of these cross sections suggests formation of the N^* (1688) as an intermediate state. (Disser. Abstr.)

3248 MUON–PROTON ELASTIC SCATTERING AT HIGH MOMENTUM TRANSFERS. von Briesen, Hans Jr. Rochester, N. Y., Univ. of Rochester, 1967. 161p.

Thesis.

A measurement of the differential cross section for muon–proton elastic scattering was performed for 4-momentum transfers between 0.62 BeV/c and 1.1 BeV/c (10 to 31 f^{-2}). The aim of the experiment was to test for any difference between the electromagnetic interactions of the muon and the electron by direct comparison with measurements of electron–proton elastic scattering. The results indicate a muon–electron electromagnetic difference; the indication is uncertain, however, because of the possibility of a 4% to 10% error in the normalization of both this experiment and the electron–proton scattering data. A quantitative limit on the magnitude of the difference is given in terms of the ratio of the μ-p elastic scattering cross section to the equivalent e-p cross section, expressed in the form $[(d\sigma/dq)\mu\text{-}p/(d\sigma/dq)e\text{-}p] = 1/(1 + q^2/D^2)^2$, where q^2 is the square of the 4-momentum transfer. This experiment establishes $D^2 > 70\ f^{-2}$ (i.e., $D < 1.65$ BeV/c) with 95% confidence. (TSS) (Disser. Abstr.)

3249 AN EXPERIMENTAL MEASUREMENT OF COSMIC RAY MUON SCATTERING BY ALUMINUM, IN THE MOMENTUM REGION OF 1.60 GeV/c. Beery, Ronald Wilbur. East Lansing, Mich., Michigan State Univ., 1966. 165p.

Thesis.

An account is presented of an investigation into the scattering behavior of $(1.60 + 0.05, -0.04)$ Bev/c μ^+ mesons from cosmic rays. The muons were allowed to traverse a spark chamber triggered by a counter telescope. The aluminum plates of the spark chamber provided the scattering material for the incoming muons. A description of circuits and equipment developed for this experiment is presented. Momentum selection was made by using a lead absorber to slow muons having the above momentum, stopping them in a scintillation counter. Final selection of events required observation of a proper μ-e decay signature in oscilloscope photographs made of the signal from the stopping scintillation counter. The oscilloscope display was also arranged to distinguish between protons, pions, and the desired muons. This served as a method of eliminating the former two types of events from the muon data. As a further verification of the particle selection, the apparent muon lifetime was measured and was in excellent agreement with the accepted value. The narrow limits of momentum obtained and the positive particle-identification procedure represent an improvement over previous cosmic-ray experiments of this kind. The track photographs obtained were measured on semi-automatic scanning equipment, the output of which was analyzed by a computer program developed for this experiment to determine the scattering angle of the particle in the chamber. Details of this analysis program are presented. The results of the scattering measurements, in the form of an integral distribution of projected angles, are compared with the distributions predicted by the theories of Moliere, of Copper and Rainwater, and of Drell and Schwartz. Details of the computer calculations required for the theoretical predictions are also presented. The results of the present experiment demonstrate agreement with both the theory of Copper and Rainwater and of Drell and Schwartz throughout the range of scattering angles observed: 0 to 4.5 degrees. This range corresponds to momentum transfers up to 190 MeV/c. Good agreement with Copper–Rainwater and somewhat better agreement with Drell–Schwartz rather than with Moliere is clear. This experiment does not display the excessive appearance of high-angle scattering reported in early cloud chamber experiments with cosmic-ray muons. This experiment, using cosmic-ray muons, corroborates the results of the recent experiment performed by Masek et al., with 2 Bev/c muons obtained from the Bevatron. (Disser. Abstr.)

3250 POLARIZATION OF Λ HYPERONS IN THE REACTION $\gamma + p \rightarrow K^+ + \Lambda$. Edwards, Helen Thom. Ithaca, N. Y., Cornell Univ., 1966. 178p.

Thesis.

The polarization of Λ hyperons, perpendicular to the production plane, was measured for the reaction $\gamma + p \rightarrow K^+ + \Lambda$ using the 1.4 GeV electron synchrotron. Measurements at approximately 90 degrees in the CMS were made for five photon energies ranging from 1000 to 1120 MeV in the laboratory. The results obtained show that the Λ is about 30% polarized in the direction $(\vec{p}_\gamma \times \vec{p}_\Lambda)$ where $\vec{p}_\gamma$ and $\vec{p}_\Lambda$ are, respectively, the momenta of the photon and the Λ. The experimental arrangement incorporated a magnetic spectrometer for the detection of the K^+ mesons, and a system of two identical counter telescopes positioned above and below the production plane for the detection of the protons from the asymmetric decay of the associated Λ hyperons. The kinematics of the reaction was determined by the aperture of the K meson spectrometer. The polarization of the Λ was related to the ratio of the number of decay protons detected in the two telescopes and was determined by an expression of the form $P(up) = N_u - N_d/N_u + N_d\ (\alpha <| \cos \theta' |>)^{-1}$ where P(up) is the polarization in the direction up, out of the production plane, N_u and N_d are the number of protons detected in the upper and lower telescopes respectively, α is the decay asymmetry parameter, and $<| \cos \theta' |>$ is a kinematic factor which depends upon the geometry of the telescopes. The events N_u and N_d were detected by photographically recording pulses from the decay telescopes, using a four beam oscilloscope. The oscilloscope sweep was triggered by a K^+ meson detected in the spectrometer, and the oscilloscope records were then scanned for coincidences between the decay telescopes and the K trigger. (Disser. Abstr.)

Weak

3251 STUDY OF THE ISOTROPY IN $\pi^+\mu^+$ DECAY FOR STOPPING π^+. Baumann, G.; Kuhry-Gerling, M-L.; Annoni, H.

(Centre de Recherches Nucleaires, Strasbourg). Nuovo Cim. (19), 52A: 321-30(Nov. 21, 1967). (In French).

The $\pi^+\mu^+$ angular distribution of stopping π^+ is analyzed in nuclear emulsions. The isotropic distribution obtained is in good agreement with the well-known spin value J = 0 of the π^+ meson. (auth)

3252 A MODEL FOR K_{e5} DECAY. Intemann, G. W.; Lapidus, I. R. (Stevens Inst. of Tech., Hoboken, N. J.). Nuovo Cim. (10), 52A: 432-7(Nov. 21, 1967).

The rate for K_{e5} decay is computed using a pion-pole model. A large enhancement is found over previous estimates based on direct interaction and η-pole models. (auth)

3253 HELICITY OF ELECTRONS FROM μ^- DECAY. Schwartz, Daniel M. (Univ. of Chicago). Phys. Rev., 162: 1306-19(Oct. 25, 1967).

The helicity of electrons from μ^- decay was measured using the spin dependence of electron–electron (Møller) scattering. A magnetized foil (Supermendur) was used as a target of polarized electrons. Optical spark chambers, scintillators, and decision-making spark chambers were used to detect the scattering events, and the pictures were measured with an automatic film scanning system (CHLOE). The experimental method and the data processing system reduced the systematic error due to background events below that of previous experiments. The helicity was found to be -0.89 ± 0.28. (auth)

3254 MEASUREMENT OF THE $K^+_{\pi 2}$ BRANCHING RATIO. Bowen, David Ralph. Philadelphia, Univ. of Pennsylvania, 1966. 90p.

Thesis.

The $K^+_{\pi 2}$ branching ratio was measured in a spark chamber and counter experiment. A 530 MeV/c K^+ beam was brought to rest in a plastic scintillator. K^+ mesons were identified by range, momentum, and time of flight from the accelerator internal target. Decay particles leaving the target at right angles to the beam passed through six thin plate spark chambers located in a 7.5 kg magnetic field. Positrons were identified by a threshold gas Čerenkov counter placed behind the magnetic field. The range of decay particles was measured in a thick plate spark chamber placed behind the Čerenkov counter. Events accompanied by a π^o, e.g., $K^+_{\pi 3}$ decay, were suppressed by ray detectors. The relative solid angle for high momentum particles was 7.5×10^{-3}. $K^+_{\pi 2}$ events were further identified as having a decay time consistent with the K^+ lifetime, as having the proper momentum, as having a range shorter than the range of muons from $K^+_{\mu 2}$ decay, and as having a position in the range chamber consistent with multiple scattering after the momentum chamber. An estimated 15% of all $K^+_{\pi 2}$ decays pass these criteria. Seven (7) such events were observed, with a background of 2.8 events. The $K^+_{\pi 2}$ branching ratio is measured to be $(2.0^{+}_{-}{}^{0.8}_{1.2}) \times 10^{-5}$, to be compared with the V–A prediction, which, including radiative corrections, is 1.45×10^{-5}. (Disser. Abstr.)

Strong (Baryon-Induced)

Refer also to abstracts 2420, 2825, 2826, 2831, 2836, and 3236.

3255 PRODUCTION OF ^{8}He IN HIGH-ENERGY INTERACTIONS WITH EMULSION NUCLEI. Baumann, G.; Gerber, J.-P.; Bechdolff, A.; Cuer, P. (Centre de Recherches Nucleaires, Strasbourg). Nuovo Cim. (10), 51B: 483-6(Oct. 11, 1967). (In French).

The ^{8}He nuclei production is studied in high-energy interactions of protons, antiprotons, π^- and K^- mesons with emulsion nuclei. The production rate was found to be $(1.33 \pm 0.52)(10^{-4})$. (auth)

3256 PHASE-SHIFT ANALYSIS OF HIGH-PRECISION (p,p) POLARIZATION DATA AT 19.7 MeV. MacGregor, Malcolm H. (Univ. of California, Livermore); Wright, Robert M.; Arndt, Richard A. Phys. Rev. Lett., 19: 1209-12(Nov. 13, 1967). (UCRL-70673).

A recent high-precision (p,p) polarization measurement at 19.7 MeV was phase-shift analyzed. It is not consistent with other (p,p) measurements at nearby energies. (auth)

3257 PRODUCTION OF HIGH-MOMENTUM DEUTERONS FROM NUCLEI BOMBARDED BY 1-GeV PROTONS. Sutter, R. J. (Brookhaven National Lab., Upton, N. Y.); Friedes, J. L.; Palevsky, H.; (and others). Phys. Rev. Lett., 19: 1189-91 (Nov. 13, 1967). (BNL-11798).

Using a magnetic spectrometer and a time-of-flight system to separate deutrons from protons, measurements of proton reactions with helium-4, lithium-6, oxygen-16, and natural lead were carried out at forward deuteron angles from 5 to 15°. All results are consistent with the reaction $p + (A,Z) \rightarrow d + p + (A-2, Z-1)$. The typical deuteron mementum spectra is shown for helium and oxygen, and the sum energy spectrum for all coincident events in which the ratio of proton to deuteron kinetic energies lies between 0.084 and 0.045 is given. From the scattering kinematics and the large average kinetic energy of the nucleon clusters (about half that of the individual nucleons) it is concluded that n–p pairs can move rather freely through the nucleus. (J.F.P.)

3258 EXPERIMENTAL CONFIRMATION OF R-MESON STRUCTURE. Dubal, L.; Focacci, M. N.; Kienzle, W. ; (and others) (CERN, Geneva). Nucl. Phys., B3: 435-40(1967).

Experimental confirmation of the structure in the region of the R(1700) meson in the reaction $\pi^- + p \rightarrow p + R^-$, reported earlier at incident pion momenta of 7 and 12 GeV/c, has been obtained at 11.5 GeV/c with the missing-mass spectrometer. The peaks $R_1(1630)$, $R_2(1700)$ and $R_3(1748)$ have been observed; in addition a peak at 1830 ± 15 MeV, reported by the CERN–Liverpool bubble chamber group, is indicated. Speculative comparison of the peaks and bubble chamber data with the L-excitation quark-antiquark model predictions gives a suggestive agreement in both mass separations and G-parities; however, this can not be excluded as being coincidence. (auth)

3259 CLASSICAL AND QUANTUM RESTRICTIONS ON THE DETECTION OF WEAK ACTIONS ON A MACROSCOPIC OSCILLATOR. Braginskii, V. B. (Moscow State Univ.). Zh. Eksp. Teor. Fiz., 53: 1434-41(Oct. 1967). (In Russian).

The weakest force whose effect on a macroscopic oscillator can be detected may depend on the friction coefficient relating the oscillator mass and the laboratory, and on the time required for the measurement. If the friction coefficient is so small that the relaxation time of the oscillator is greater than the time spent in the measurement, a change of the oscillator energy induced by an external force can be determined reliably which is smaller than the equilibrium quantity $\varkappa T$. The relaxation time of mechanical oscillators in laboratory conditions may exceed 10^7 sec. An example of an experiment is presented in which an energy change $\varkappa \cdot 60°K = 7{,}8 \cdot 10^{-15}$ erg could reliably be determined at $T_{eq} = 4500°K$, measurement time 23 sec and relaxation time 2400 sec. The role of quantum fluctuations in a Fabry–Perot optical resonator employed for recording small vibrations of a mechanical oscillator is discussed. Approximate expressions for the smallest detectable forces are derived by taking into account the finite time spent in the measurement. It is shown that a decrease of spectral density of the fluctuation power modulation coefficient of the optical source and narrowing of the natural line width lowers the level of the minimal detectable forces. Estimates of the principally attainable sensitivity level in experiments dedicated to a verification of the equivalence principle, or in experiments in which particles with fractional charges are searched for and in experiments on detection of gravitational radiation are presented. (auth)

3260 MULTIPLE PION PRODUCTION IN 5.5-GeV/c π^-p INTERACTIONS. Bomse, Frederick; Borenstein, Samuel; Brucker, E. Byerly; (and others). (Johns Hopkins Univ., Baltimore). Phys. Rev., 162: 1328-34(Oct. 25, 1967).

About 2000 six-prong events and 130 eight-prong events from an exposure in the Brookhaven 80-in. bubble chamber were analyzed. Production of Δ^{++} (1238), Δ^- (1238), and ω^0 resonances was observed. The distribution of Δ^{++} and ω^0 as a function of four-momentum transfer was similar to that of background. Center-of-mass angular distributions of the nucleons and pions were examined. The nucleons were peaked backward and the pions were essentially isotropic with a slight forward peaking in the π^+ case. (auth)

3261 COMPARISON OF ISOBAR PRODUCTION IN pp AND $\bar{p}n$ INTERACTIONS AT 2.8 GeV/c. Bacon, T. C.; Bomse, F. M.; Cochran, T. B.; Fickinger, W. J.; Goza, E. R.; Hopkins, H. W. K.; Salant, E. O. (Vanderbilt Univ., Nashville). Phys. Rev., 162: 1320-2(Oct. 25, 1967).

The reactions $pp \rightarrow N^{*++}(1238)n$ and $\bar{p}n \rightarrow \bar{N}^{*--}(1238)p$ at 2.8 GeV/c incident laboratory momentum are analyzed with the Brookhaven National Laboratory 20-in. bubble chamber. Isobar and anti-isobar production differential cross sections and decay angular distributions are compared with the predictions of an absorptive single-pion-exchange model. The absolute values, shapes, and ratios of the cross sections are in good agreement with the theory when the absorptive parameters γ_1 and γ_2 are 0.033 and 0.016 for the $\bar{p}n$ reaction, and 0.057 and 0.019, respectively, for the pp reaction. (auth)

3262 PROTON–PROTON ELASTIC SCATTERING AT INCIDENCE MOMENTA 3, 5, AND 7 BeV/c. Clyde, Allan Roy. Berkeley, Calif., Univ. of California, 1966. 111p.

Thesis.

Differential cross sections for p-p elastic scattering were measured for incident momenta, 3, 5, and 7 BeV/c. The backward scattered protons were momentum analyzed with magnetic spectrometers and detected with scintillation counters for the missing mass spectrum of $p + p \rightarrow p + x$ for x = a proton. A hydrogen gas target was used for recoil momenta from 75 to 600 MeV/c and polyethylene with matched carbon for subtraction was used from 500 to 4000 MeV/c. Statistical errors were approximately 2% at low momentum transfer, and increased to about 5% for 90° scattering in the center-of-mass. The data indicates shrinkage of the diffraction peak with incident energy, a strong energy dependence of $d\sigma/d|t|$ at 90° and is consistent with a logarithmic decrease in the total elastic cross section with the center-of-mass energy. The behavior of the forward scattering indicates the presence of a real scattering amplitude. The values obtained for the ratio of the real to the imaginary scattering amplitudes are 43, 39, and 34% respectively. An assumption of similar angular dependence of the real and imaginary parts of the nucleon scattering amplitude is indicated by these data. (Disser. Abstr.)

3263 NEUTRON–PROTON ELASTIC SCATTERING FROM 1 TO 6 GeV. Kreisler, Michael Norman. Stanford, Calif., Stanford Univ., 1966. 123p.

Thesis.

The first measurements of neutron-proton elastic scattering from 1 to 6.3 GeV were made using spark chambers. A well-collimated neutron beam produced by the external proton beam of the bevatron interacted in a liquid hydrogen target. The recoil proton momentum and angle were measured with a bending magnet and spark chambers, and the scattered neutron angle was measured with an array of steel plate spark chambers. The entire system was on rails to allow coverage of cms angles from about 10 to 150°. The results based on 6219 elastic events are presented as differential cross sections versus the four momentum transfer squared, $|t|$, in 1 GeV energy intervals. The small angle region cross sections are roughly exponential in behavior. A least square fit of the cross sections to $d\sigma/d|t| = A \exp(b|t|)$ in the range $0.2 \leq |t| \leq 0.6$ $(GeV/c)^2$ yields b to be -6.321 ± 0.647, -5.527 ± 0.463, -6.655 ± 0.432, -7.720 ± 0.411, and -7.562 ± 0.391 $(GeV/c)^{-2}$ for energy intervals 1.0–2.0, 2.0–3.0, 3.0–4.0, 4.0–5.0, and 5.0–6.3 GeV respectively. Shrinkage of the diffraction peak is observed and found to be similar to proton-proton scattering. No statistically significant secondary peak is observed. The large angle measurements indicate symmetry around 90° in the cms with the minimum in the cross sections at or just beyond 90°. The data are consistent with an exponential decrease on the large angle cross sections with the total cms energy. (Disser. Abstr.)

3264 DEUTERON PRODUCTION IN PROTON–PROTON COLLISIONS FROM 1.5 TO 3 GeV. Pellett, David Earl. Ann Arbor, Mich., Univ. of Michigan, 1966. 165p.

Thesis.

The differential cross section for deuteron production in proton-proton collisions was measured for incident proton kinetic energies of 1.55, 2.5, and 2.9 GeV. Measurements were made at laboratory angles of 5.9, 11.55, 15.72°, and, at the two higher energies, at 20° relative to the beam direction for deuteron laboratory momenta in the range 1.0–2.4 GeV/c. The experiment was performed in an external proton beam of the cosmotron. A system of scintillation and Čerenkov counters was used to identify deuterons by momentum analysis and time-of-flight techniques. The differential cross sections are presented in the laboratory and center of mass (cm) systems. Plots are given of the cross section versus the invariant mass of the system of particles formed with the deuteron in the collisions. Total cross sections were obtained by integrating a smooth function fitted to the cm data at each energy. The deuteron distributions in the laboratory system were peaked at small angles relative to the beam direction. All deuterons were formed with momenta >1.0 GeV/c. The cm differential cross section distributions obtained at the three energies of this experiment showed a general similarity to one another. The cross section was sharply peaked in the forward and backward directions for large cm momenta. The maximum became more broad as the momentum decreased until the cross section was almost isotropic. There was evidence of structure in the broad maximum at intermediate momenta. The total deuteron production cross section decreased monotonically with incident proton kinetic energy from 310 ± 25 μb at 1.5 GeV to 137 ± 21 μb at 2.9 GeV. The interpolated value at 2.3 GeV was consistent with the statistical model prediction. The cross section for production of deuterons associated with two or more pions had a maximum near 2 GeV. A search for pion resonances of unit isotopic spin in the mass range 400–1000 MeV through reactions of the form $p + p \rightarrow d + x^+$ yielded evidence for ρ production. At 2.5 GeV, the ρ production cross section was small ($\sigma_{total} \lesssim 9$ μb) and did not appear to be sharply peaked in the forward and backward directions. Upper limits were set for the production of the ζ (560 MeV) and the X^+ (960 MeV) resonances. The laboratory distributions in momentum and angle of deuterons produced in proton–proton collisions at 2.9 GeV were found to be much different from those arising from proton–beryllium and proton–platinum collisions at the same energy. The total deuteron production cross section per nucleon was approximately six times greater in collisions of protons with beryllium than in collisions with other protons, indicating that specifically nuclear processes are at work in the former case. (Disser. Abstr.)

Strong (Meson-Induced)

Refer also to abstracts 2825 and 3255.

3265 (CEA-R-3291) INTERACTIONS $\pi^-p \rightarrow \pi^-\pi^0p$ A 2.15 GeV/c. (The $\pi^-p \rightarrow \pi^-\pi^0p$ Interaction at 2.15 GeV/c). Baton, Jean-Pierre (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Sept. 1967. 22p. (In French). Dep.

A study of the reaction $\pi^-p \rightarrow p\pi^-\pi^0$ for low values of the four momentum transferred to the proton was carried out with the 180 l liquid hydrogen bubble chamber exposed to a π^- beam of 2.15 GeV/c. Production and decay properties of the $\rho^- \rightarrow \pi^-\pi^0$ meson are described. (auth)

3266 (CERN–67-30) ARE PION–PION SCATTERING EXPERIMENTS FEASIBLE. Csonka, Paul L. (European Organization for Nuclear Research, Geneva (Switzerland)). Oct. 12, 1967. 38p. Dep.

The significance and feasibility of observing the scattering of two real pions on each other is discussed. The importance of new machines, storage rings, and unconventional techniques is emphasized. Order of magnitude estimates are given for the following: low laboratory energy pions, and scattering in minirings; for high laboratory energy pions, self-clashing and head-on colliding of pion beams. The estimates include machines now working or planned, all without and also in combination with storage rings. (J.F.P.)

3267 (INR–828/VI/PH) ENERGY ESTIMATION IN COLLISIONS OF VERY HIGH ENERGY PIONS WITH NUCLEI OF PHOTOGRAPHIC EMULSION. Gierula, J.; Krzywdzinski, S. (Institute of Nuclear Research, Warsaw (Poland)). 1967. 12p. Dep.

On the basis of about 500 interactions of particles with energy of few hundred GeV with nuclei of photographic emulsion a systematic dependence of the median emission angle of secondary particles on the number of evaporation prongs was found. In consequence the corrections to the energy estimates calculated by the Castagnoli method were obtained. (auth)

3268 (ORO-2504-109) A STUDY OF FINAL STATES WITH A $K\bar{K}$ PAIR PRODUCED BY 4.25 GeV/c K^- MESONS IN HYDROGEN. Technical Report No. 720. Abrams, Gerald Stanley (Maryland Univ., College Park. Dept. of Physics and Astronomy). Sept. 1967. Contract AT(40-1)-2504. 204p. Dep. CFSTI.

Thesis.

Final states in which both K and $\bar{K}$ mesons are produced in hydrogen were analyzed at a K^- beam momentum of 4.25 BeV/c. A main concern of this experiment was a study of strangeness −2 baryon states. Weak evidence is presented for the detection of the $\Xi^*(1815)$ found at lower energies. The data offer no other evidence of Ξ^* resonance production. The ϕ meson was found to be produced relatively copiously, both in the $\Lambda\phi$ and in the $\Sigma\phi\pi$ states. The mass and width of the ϕ was measured using the $\Lambda\phi$ events, and the results compared to other measurements. The production of the ϕ mesons appears to be mediated by K and K^* exchange. Evidence was found supporting the existence of the $f^*(1500)$. Evidence for a $K_1^0K_1^0$ enhancement near 1600 MeV was found; the data do not demand a resonance interpretation. Formation of $K^*(890)$, $Y_0^*(1405)$, $Y_1^*(1385)$ and $Y_1^*(1520)$ are also indicated by the data. There also exists indications that the D, E, $\pi_v(1003)$ and $\eta_v(1050)$ may be produced. The most significant results of this experiment are the lack of any outstanding structure, and the small values of the observed cross sections. (auth)

3269 (UR–875–218) ANTIHYPERON, HYPERON, AND TWO-BODY REACTIONS IN 13 GeV/c K^+p COLLISIONS. Berlinghieri, J. C.; Farber, M. S.; Ferbel, T.; Forman, B.; Mesissinos, A. C.; Yamanouchi, T.; Yuta, H. (Rochester Univ., N. Y. Dept. of Physics and Astronomy). Sept. 14, 1967. Contract AT(30-1)-875. 19p. Dep. CFSTI.

A preliminary analysis of three-body reactions involving $\bar{Y}$ and Y production in 12.7 GeV/c $K^+ + p$ interactions, and the production

of quasi two-body final states in the reactions $K^+ + p \rightarrow K^0 + p + \pi^+$, $K^+ + p \rightarrow K^0 + p + \pi^+ + \pi^0$, and $K^+ + p \rightarrow K^+ + p + \pi^+ + \pi^-$. The film is from 80,000 exposures of the 80-inch liquid hydrogen chamber to an rf separated beam. (J.F.P.)

3270 $\pi^- + p$ ELASTIC SCATTERING IN THE NEIGHBOURHOOD OF N^*_γ (2190). Busza, W. (London Univ.); Davis, D. G.; Duff, B. G.; (and others). Nuovo Cim. (10), 52A: 331-41 (Nov. 21, 1967).

Elastic $\pi^- + p$ differential cross section data are presented at the incident-pion momenta 1.72, 1.89, 2.07, 2.27, and 2.46 GeV/c. Resonant behavior in the coefficients of a Legendre polynomial expansion indicates a G- or H-wave resonance. Further analysis using an energy-dependent parametrization of G- and H-waves shows the results to be compatible with the $^7/_2^-$ assignment for the $N^*_\gamma(2190)$, but equally acceptable solutions are obtained with the inclusion of an additional $^9/_2^+$ resonance contribution. (auth)

3271 ANTIPROTON–PROTON ANNIHILATION INTO KAONS AND PIONS IN THE MOMENTUM REGION 3 TO 4 GeV/c. French, B. R. (CERN, Geneva); Kinson, J. B.; Rigopoulos, R.; Simak, V.; McDonald, F.; Petmezas, G.; Riddiford, L. Nuovo Cim. (10), 52A: 438-57(Nov. 21, 1967).

A total of 1121 unambiguously identified events of the type $\bar{p}p \rightarrow \bar{K}K\ n\pi$ (n = 1 to 5) at momentum 3.0, 3.6, and 4.0 GeV/c were analyzed, and partial cross sections for the various channels are given. The total cross sections for annihilation into two kaons with pions is estimated to be (5.1 ± 0.4) mb or 14% of all annihilations. The amounts of resonant K*(890), ρ, ω and associated K*K* production in the various channels are determined. Evidence for the E-meson, a $KK\pi$ resonance at 1700 MeV, and a $K^*\pi$ resonance at 1265 MeV is presented. Study of 955 unfitted events containing two charged particles, a K^0_1 and ≥ 2 neutral secondaries gives rise to a four-standard-deviation peak in a strangeness-zero mass spectrum at (1820 ± 12) MeV with a width (Γ) of (50 ± 23) MeV. The angular distributions favor a peripheral rather than a statistical or core-core model of the annihilation process. The possible usefulness of weighting the various combinations in accord with this observation, to accentuate enhancements in the invariant-mass distribution, is discussed. A method of separating each annihilation into its most likely two-body final-state configuration based on maximizing the four-momentum transfer (u) in the cross channel is presented as well as some examples of the enhancements in mass spectra obtained using this method. (auth)

3272 STUDY OF $\pi^-\pi^0$ ELASTIC SCATTERING BY THE EXTRAPOLATION METHOD OF CHEW AND LOW FROM THE REACTION $\pi^-p \rightarrow \pi^-\pi^0p$ AT 2.77 GeV/c. Baton, J. P.; Laurens, G.; Reignier, J. (CEN: Saclay, France). Nucl. Phys., B3: 349-62(1967). (In French)

The Chew–Low extrapolation method is used to study the $\pi^-\pi^0$ elastic scattering from a high statistics $\pi^-p \rightarrow \pi^-\pi^0p$ experiment. The $\pi^-\pi^0$ elastic cross section and the S_3 and P_1 phase shifts are given up to one GeV, and also some qualitative information on the D_3 phase shift. The P_1 phase shift goes through 90° in the ρ mass region which gives a firm basis to the interpretation of the ρ as a $\pi\pi$ resonance. It is also found that the use of form factors to get this information without extrapolation is not correct. (auth)

3273 AK ENHANCEMENT AT 1.7 GeV PRODUCED IN $\pi p \rightarrow AK\pi$ INTERACTIONS AT 6 GeV/c. Crennell, David J.; Lai, Kwan Wu; Scarr, J. Michael; Schumann, Thomas G. (Brookhaven National Lab., Upton, N. Y.). Phys. Rev. Lett., 19: 1212-15 (Nov. 13, 1967). (BNL-11770).

A marked AK^+ enhancement centered at 1.7 GeV with a width of 0.17 GeV in the interaction $\pi^-p \rightarrow AK^+\pi^-$ at 6 GeV/c was observed. This effect does not show up strongly in the similar interactions $\pi^+p \rightarrow AK^{+,0}\pi^{+,0}$. The production mechanism is discussed in terms of s (direct) and t (crossed) channels, and the question of whether this enhancement is associated with the $N^*_\gamma(1688)$ is examined. (auth)

3274 EVIDENCE FOR THE EXISTENCE OF THE HYPERNUCLEUS $_\Lambda Li^6$. Harmsen, Dirk-Michael (Univ. of Chicago). Contract AF 49(638)-1552. Phys. Rev. Lett., 19: 1186-9(Nov. 13, 1967).

An event was observed in nuclear emulsions which is attributed to the decay of a $_\Lambda Li^6$ hypernucleus, $_\Lambda Li^6 \rightarrow \pi^- + p + p + {}^4He$, with a total binding energy of B = 3.92 ± 0.37 MeV relative to the free-particle system $\Lambda + p + {}^4He$. (auth)

3275 COMPUTATION OF ELASTIC PION–PION CROSS-SECTION FROM 1.7 GeV/c $\pi^-p \rightarrow \pi^-\pi_0$. TEST OF THE FERRARI–SELLERI FORM FACTOR. Allen, D. D.; Fisher, G. P.; Godden, G.; Kopelman, J. B.; Libby, L. Marshall; Sears, R. (Univ. of Colorado, Boulder). Nuovo Cim. (10), 52A: 286-90(Nov. 1, 1967).

An inconsistent behavior of the Ferrari–Selleri phenomenological form factor for the pion–nucleon vertex in a computation of the pion–pion cross section using the reaction $\pi^- + p \rightarrow \pi^- + p + \pi^0$ at 1.7 GeV/c incident laboratory momentum is reported. The inconsistency is such that the usefulness of this form factor appears to be in considerable doubt. The comparison of two methods shows disagreement if the Ferrari–Selleri or Amaldi–Selleri form factor is used even when taken as unity. To make this comparison the low-four-momentum component was selected from 2112 events of the studied reaction measured in a hydrogen bubble chamber. (J.F.P.)

3276 MULTIPION FINAL STATES FROM π^-p INTERACTIONS AT 3.2 AND 4.2 GeV/c. Chung, Suh Urk. Berkeley, Calif., Univ. of California, 1966. 143p.

Thesis.

Approximately 30,000 four-prong events were analyzed at π^- beam momenta of 3.2 and 4.2 GeV/c, obtained with the 72-inch hydrogen bubble chamber. All the effective-mass distributions obtainable from the final states $p\pi^+\pi^-\pi^-$, $p\pi^+\pi^0\pi^-\pi^-$, and $n\pi^+\pi^+\pi^-\pi^-$ are presented as well as the cross sections of these final states. In addition, the results of the study of the quasi-three-body final states $N^{*++}(1238)\pi^-\pi^-$, $p\pi^-\rho^0$, $p\pi^-\omega$, and $p\pi^-\eta$ are presented. Particular emphasis is given to the production and decay of the A_1, A_2, and B enhancements; the A_1 and B enhancements observed in the data are consistent with the interpretations as kinematic enhancements, and the A_2 enhancement can be interpreted only as a genuine resonant state. From the study of the decay angular correlations in the A_2 region as well as the control regions, it was determined that the lowest possible quantum numbers of the A_2 are $J^P = 2^+$. (Disser. Abstr.)

3277 THE REACTION $\pi^- + p \rightarrow$ ALL NEUTRALS AND ASSOCIATED ISOBAR PRODUCTION. Yamin, Samuel Peter. Philadelphia, Univ. of Pennsylvania, 1966. 112p.

Thesis.

An investigation of the $\pi^- + p \rightarrow$ (all neutrals) total cross section for incident π^- momenta of 784 to 5290 MeV/c is described. To study the total cross section, the stopping rate of pions in a liquid target was measured by means of a beam telescope and a 4π anticounter surrounding the target. Heavy-plate spark chambers were used to determine the gamma ray (and hence π^0) final state multiplicities. Corrections for strange particle production are applied to the neutral data. Evidence for structure at cms energies of 1682, 1900, and 2180 MeV appears in the neutral data. This structure was identified with the previously established N*(1688), N*(1920), N*(2190), and N*(2360) isobars. The relation of the data to previous pion photoproduction and π-N scattering experiments is discussed. It is observed that with the completion of the experiment a consistent quantum number assignment is found for the isobars appearing in all charge modes of pion-nucleon scattering having a mass of less than 1920 MeV. (Disser. Abstr.)

3278 π^+–p INTERACTIONS AT 900 MeV. Metzger, Wesley James. Rochester, N. Y., Univ. of Rochester, 1967. 138p.

Thesis.

The 20-inch liquid hydrogen bubble chamber was exposed to a separated beam of π^+ mesons, having a laboratory momentum of 1.02 Bev/c. In 18,500 frames, about 6000 events were found and measured. Cross sections for the following reactions were measured: $\pi^+p \rightarrow \pi^+p$, $\pi^+ + p \rightarrow \pi^+p\ \pi^0$, $\pi^+ + p \rightarrow \pi^+\ p\ e^+e^-$, $\pi^+ + p \rightarrow \pi^+\pi^+n$, $\pi^+ + p \rightarrow$ 2 charged particles + 2 or more neutrals, and $\pi^+ + p \rightarrow$ four charged particles. An intensive study of evidence for the existence of the zeta meson was made in these data and in previously published data. The conclusion of this study is that there is no experimental evidence for the existence of the zeta. (TSS) (Disser. Abstr.)

3279 πp ELASTIC SCATTERING FROM 2.3 TO 6.0 GeV/c WITH SPECIAL REFERENCE TO THE BACKWARD DIRECTION. Williams, David Gerald. Ann Arbor, Mich., Univ. of Michigan, 1966. 80p.

Thesis.

Results are presented for 7 runs of π^+p elastic scattering with π momentum from 2.3 to 4.0 BeV/c, and for 5 runs of π^-p with momentum from 2.5 to 6.0. Differential cross sections were obtained for cos θ^* = +.97 to −.94. Experimental data were obtained with spark chambers, and a fully automatic scanning system was used in the analysis. The differential cross section in the region behind the two forward peaks is discussed. A calculation based on the formation of intermediate N* states is presented; it fits the data between the forward peaks and the backward peak fairly well. The backward peak may be calculable on the basis of exchange of Regge trajectories, plus N* formation. The cross section for $\pi^-p \rightarrow \bar{p}d$ at 6 BeV/c is found to be less than 9.1 μb. Slopes of the backward peaks are presented, as well as upper and lower bounds for $\pi^-p \rightarrow \pi^0n$. (Disser. Abstr.)

3280 RESONANCES IN THE REACTION $K^- n \rightarrow \Sigma^- \pi^+\pi^-$ FROM 1660 TO 1900 MeV. Bell, Robert Brooks. Berkeley, Calif., Univ. of California, 1966. 84p.

Thesis.

The reaction $K^- n \rightarrow \Sigma^- \pi^+\pi^-$ was studied in the K^- n center of mass energy range from 1660 MeV to 1900 MeV. Three strangeness minus one baryon resonances are definitely observed. Two of these isobars, the $Y_1^*(1520)$ and $Y_0^*(1405)$ are produced with the negative pion and then decay into the $\Sigma^- \pi^+$ final state. The third, the $Y_1^*(1760)$, undergoes the decay $Y_1^*(1760) \rightarrow Y_1^*(1520)\ \pi^-$. It is also possible that the high energy tail of the $Y_1^*(1660)$ is present in the data. The $\Sigma^- \pi^-$ final state has isospin two and an extensive search was made for any enhancement which might indicate the presence of a Y_2^*. No evidence for the existence of a doubly charged strange resonance decaying into $\Sigma^- \pi^-$ was found anywhere in the available energy region of this experiment. It was possible to unambiguously determine the spin and parity of the $Y_1^*(1760)$ by an examination of the production angular distribution of the $Y_1^*(1520)$ produced in the reaction $K^- n \rightarrow Y_1^*(1760) \rightarrow Y_1^*(1520)\ \pi^-$ and the decay distribution of the $Y_0^*(1520)$ into $\Sigma^- \pi^+$. No information concerning the quantum numbers of the $Y_1^*(1660)$ could be obtained from the data. (Disser. Abstr.)

3281 PION–NUCLEON ELASTIC SCATTERING IN THE BACKWARD HEMISPHERE AND THE APPLICATION OF REGGE THEORY TO BACKWARD ANGLES OTHER THAN COS $\theta = -1$. Dikmen, Fikri Ned. Ann Arbor, Univ. of Michigan, 1966. 79p.

Thesis.

The differential cross sections for elastic scattering of pions by protons for laboratory pion momenta between 2.3 and 6.0 BeV/c were measured in a spark chamber experiment. Regge pole theory is applied to the differential cross sections for backward angles in the center of mass for the reaction $\pi^- p \rightarrow \pi^- p$. The fits obtained from this theory qualitatively disagree with the data. A model is suggested based on pure resonances only, to fit the backward hemisphere. (Disser. Abstr.)

3282 π^-p ELASTIC SCATTERING AT 180 DEGREES FROM 1.6 TO 5.3 GeV/c. Kormanyos, Stephen William. Ann Arbor, Mich., Univ. of Michigan, 1966. 85p.

Thesis.

The differential cross section for π^-p elastic scattering at 180° was measured in steps of 0.10 GeV/c or less in the region from 1.6 to 5.3 GeV/c. There is considerable structure in the cross section. This may be interpreted as an interference effect between the resonance amplitude and the nonresonant or background amplitude. There is a dramatic destructive interference at $P_0 = 2.15$ GeV/c which is quite interesting as the cross section drops almost two orders of magnitude in this region. Another interesting feature of the experiment is the large narrow peak in the cross section at $P_0 = 5.12$ GeV/c. It is believed that this is firm evidence for the existence of a nucleon resonance with a mass of (3245 ± 10) MeV. This N^* (3245) has a full width at half-maximum of less than 35 MeV. The width of the resonance is about 1% of its mass. Parities and the quantity $X(J + \frac{1}{2})$ are given for various N^* resonances where X is the elasticity and J is the spin of the resonance. (Disser. Abstr.)

3283 WIDE ANGLE ELASTIC SCATTERING OF PIONS FROM HYDROGEN AT 4 TO 10 GeV/c. Lanza, Richard Charles. Philadelphia, Univ. of Pennsylvania, 1966. 191p.

Thesis.

The differential cross section for elastic scattering of π^+ and π^- mesons from protons was measured using a system of scintillation counters and spark chambers for incident pion momenta of 4, 6, 8, and 10 GeV/c. The cross section was measured for center of mass pion scattering angles of approximately 140 to 165 degrees, corresponding to values of u (the square of the four-momentum transfer incident pion to emergent proton) of approximately -1.5 to -0.1 $(GeV/c)^2$. The scintillation counters were arranged in a hodoscope array which measured the emergent pion angle with respect to the beam direction and, in conjunction with a bending magnet, the emergent proton momentum-angle combination. The electronics was arranged so as to provide a rapid means of selecting the combinations of angles and momenta appropriate to wide angle elastic scatters. When the hodoscope system indicated a possible event, the spark chambers were triggered. Photographs of the chambers were then measured and the events reconstructed in space. After corrections for inelastic background, beam contamination, geometrical efficiency, dead time in the counters, and scattered particle interactions and decays, the following results were obtained: The π^+p and π^-p differential cross sections show a peak toward 180 degree pion scattering angle in the center of mass. The π^+p cross section is larger than the π^-p cross section by a factor of 10 to 20. The π^+p cross sections exhibit a "dip" at $u \approx -0.2$ $(GeV/c)^2$, independent of the center of mass energy. The π^-p cross sections show no such effect. The cross sections for π^+p and π^-p decrease with increasing center of mass energy, although the shapes of the cross sections do not appear to change. From these results, the following conclusions can be reached: The properties of the peaks, and the differences for π^+ and π^-, appear to be most readily explained by a baryon-exchange model rather than an optical model. The differences in the shapes of the peaks, and the energy dependence of the peaks, are not consistent with the predictions of a perturbation theory (pole term) calculation of the baryon exchange process. All features of the data, including the dip effect, are consistent with an exchange model in which the exchanged baryon exhibits "Regge-like" behavior. (Disser. Abstr.)

3284 Y_1^* PRODUCTION IN K^-d INTERACTIONS AT 2.24 GeV/c. Schroeder, Lee Stewart. Bloomington, Ind., Indiana Univ., 1966. 89p.

Thesis.

The production of the Y_1^* (1385) resonant state was studied in K^-d interactions at 2.24 BeV/c, by investigating the reactions: $K^- p \rightarrow \pi^+\pi^-\Lambda$, (1) $K^- n \rightarrow \pi^+\pi^-\pi^-\Lambda$, (2) and $K^- n \rightarrow \pi^+\pi^-\pi^-\Lambda\pi^0$ (3). A large sample (about $\frac{1}{3}$) of the events from reaction (1) were interpreted as being: $K^- p \rightarrow Y_1^{*+}\pi^-$ (4) from which the Y_1^{*+} decayed into a Λ and a π^-. The values obtained for the Y_1^{*+} mass and width were found to be in good agreement with the accepted values. However, the data would not permit a definitive spin and parity test for the Y_1^{*+}. The production angular distribution for the Y_1^{*+} events showed that the Y_1^{*+}'s were produced in a predominantly peripheral manner. This, along with the large Y_1^{*+}/Y_1^{*-} ratio observed for reaction (4), suggested that the production mechanism might be interpreted in terms of a single-particle-exchange model. An investigation of the Y_1^{*+} decay distribution, in the coordinate system suggested by Gottfried and Jackson, indicated that the data were consistent with about 70% of the Y_1^{*+} events being produced via the exchange of a vector meson (K^*). Other results from reactions (1) and (4) were found to be in good agreement with the results obtained in a previous K^-p experiment done at the same beam momentum. Reaction (2) showed significant Y_1^{*-} production. About $\frac{1}{3}$ of the events were interpreted as being: $K^- n \rightarrow Y_1^{*-}\pi^+\pi^-$ (effective mass about 700 MeV) (5), the majority of the remaining events being consistent with the nonresonant production of reaction (2). It was not determined whether the $\pi^+\pi^-$ system with the high effective mass was a ρ^0 meson, shifted in energy by an energy dependent cross section, or just a kinematical effect. The Y_1^{*-} mass was found to be in good agreement with the accepted value; however, the Y_1^{*-} width was found to be higher than the accepted value. Again, the data would not allow a definitive test of the Y_1^{*-} spin and parity. Reaction (2) offers the possibility of several other resonant states appearing. Evidence for some of these along with their cross sections are presented. The production angular distribution for the Y_1^{*-} events of reaction (5) indicated that the Y_1^{*-}'s were not produced peripherally, suggesting that a single-particle-exchange model might not be applicable for reaction (5). However, the large Y_1^{*+}/Y_1^{*-} ratio observed could be explained in terms of a single-particle-exchange model. In the hope of resolving the question of the production mechanism of reaction (5), the Y_1^{*-} decay distribution was studied. This study indicated that the production process, if it could be interpreted in terms of a single-particle-exchange model, might be mediated by a mixture of vector meson (K^*) and pseudoscalar meson (K). Reaction (3), although lacking statistics, showed some Y_1^{*-} production, as well as evidence for double resonance production in the reaction: $K^- n \rightarrow Y_1^{*-}\omega^0(780)$ (6). Reaction (6) appeared to make a sizeable contribution (upper limit of 25%) to reaction (3). However, due to the lack of statistics, this channel was not investigated further. A search for a charged $\eta'(960)$ was conducted among appropriate missing mass distributions. The evidence for or against the existence of a charged η' was inconclusive. (Disser. Abstr.)

3285 A STUDY OF RESONANCE PRODUCTION AND DECAY, AND ELASTIC SCATTERING IN π^-p TWO-PRONG INTERACTIONS 2.05 TO 3.22 GeV/c. Jacobs, Laurance David. Berkeley, Calif., Univ. of California, 1966. 199p.

Thesis.

An analysis of 45,000 π^-p interactions in the 72-inch hydrogen bubble chamber resulting in two charged particles are presented. The reactions $\pi^- p \rightarrow n\pi^+\pi^-$ and $\pi^- p \rightarrow p\pi^0\pi^-$ and elastic scattering were studied at 2.05, 2.17, 2.36, 2.60, 2.86, and 3.22 GeV/c. It is found that the three-body interactions are dominated by production of the ρ meson. Nucleon resonances, although present, are not important. The f^0 is seen at the three higher energies. The OPE model, modified by absorption, was used to calculate and fit the production and decay angular distributions of the ρ and to estimate the s-wave contribution to $\pi\pi$ scattering. On the basis of the model and the observed $(F - B)/(F + B)$ asymmetry in the $\pi^+\pi^-$ state, good agreement with the experimental data in the ρ region is found, if δ_1^1 is allowed to increase slowly through $\pi/2$. A

resonant isoscalar s-wave amplitude is not required. The diffraction peak in π^-p elastic scattering was fitted to an exponential form, and it is found that between 2.0 and 2.5 GeV/c the exponential slope varies. This behavior is linked to the presence of resonances in the s channel. The fast decrease of the secondary peak is linked to the exchange of the P' Regge trajectory in the t channel. Evidence is shown for production of the A_2^- in $\pi^-p \rightarrow \pi^-p$ + missing mass. (Disser. Abstr.)

3286 MESONS AND SPECTATOR PROTONS IN $\pi^+d \rightarrow \pi^+\pi^-\pi^0$ pp AT 3.65 GeV/c. Benson, George Carl. Ann Arbor, Mich., Univ. of Michigan, 1966. 255p.

Thesis.

There were 250,000 pictures in the 20-in. deuterium bubble chamber. The chamber was exposed to 3.65 BeV/c π^+ mesons. The following π^+d cross sections were determined for the final states (in mb): (m π^0)pp, m ≥ 1 (1.95 ± 0.19); $\pi^+\pi^-$pp (2.58 ± 0.21); $\pi^+\pi^-\pi^0$pp (3.44 ± 0.31); and $\pi^+\pi^-$(mπ^0)pp, m ≥ 2 (2.88 ± 0.35). The $\pi^+\pi^-\pi^0$pp state which is studied consists of 2993 events. The cross sections for the resonant states which contribute 58% of the $\pi^+\pi^-\pi^0$ pp cross section are (in μb): ρ^+ (480 ± 70), ρ^0 (400 ± 60), ρ^- (360 ± 50), η^0 (50 ± 10), ω^0 (460 ± 50), and N^{*++}(1238) (250 ± 40). Cross sections of states which contribute to the ρ-meson cross sections are (in μb): ρ^+N^{*0}(1238) (180 ± 20), ρ^0N^{*+}(1238) (180 ± 20), H^0 (80 ± 20), and A_2^0 (170 ± 30). Masses and full widths were determined (M in MeV, Γ in MeV) for: η^0 (551 ± 3, ---), ω^0 (783 ± 2, 21 ± 6), H^0 (998 ± 10, 45 ± 30), A_2^0 (1310 ± 10, 100 ± 15), and ρ^+ (771 ± 11, 190 ± 45). A spin determination for the H^0 favored $J^P = 1^+$. For the A_2^0 the leading J^P and χ^2 probabilities of the spin test were (2^+, 55%) and (1^+ s-wave, 2%). Assuming the most probable spin in each case, the measured density matrix diagonal elements were: $\omega^0(\rho_{00} = 0.40 \pm 0.04)$, $H^0(\rho_{00} = 0.57 \pm 0.06)$, and $A_2^0(\rho_{00} = 0.14 \pm 0.02$, $\rho_{22} = 0.12 \pm 0.06)$. A study of the percentage of spectator protons with momenta greater than 250 MeV/c showed differences in states with different numbers of out-going pions. When the percentage was plotted as a function of Δ^2 (mesons), there was no difference in final states. A decrease of this percentage with increasing mass (mesons) was found in each channel, but the dependence was the same in each channel studied. (Disser. Abstr.)

3287 MEASUREMENT OF POLARIZATION IN NEGATIVE PION–PROTON SCATTERING FROM 229 TO 390 MILLION ELECTRON VOLTS. Arens, John Frederic. Berkeley, Calif., Univ. of California, 1966. 49p.

Thesis.

The π^-p polarization parameter was measured at several energies and angles using a polarized proton target at the 184'' cyclotron. The data at 229 MeV covered the angles between 150° and 180° in the cms; at 318, 337, and 390 MeV the angles between 70° and 180° were included. Scintillation counter hodoscopes were used in coincidence to detect both the pions and recoil protons. A small computer was used on-line to facilitate data handling and storage on magnetic tape. Phase shift analyses using this and other published data were made at the two lowest energies. (Disser. Abstr.)

Particle Interactions and Properties (Theoretical)

General

Refer also to abstract 3532.

3288 (CERN–66-29(Vol.3)) PROCEEDINGS OF THE 1966 CERN SCHOOL OF PHYSICS, NOORDWIJK AAN ZEE, JUNE 6–18, 1966. (European Organization for Nuclear Research, Geneva (Switzerland)). Aug. 10, 1967. 165p. Dep.

There were 3 lectures included. Separate abstracts were prepared for each lecture. (J.F.P.)

For abstracts of individual lectures see: 3402, 3482, and 3554.

3289 (INP–555/PL/PH) PROCEEDINGS OF THE VII CRACOW SCHOOL OF THEORETICAL PHYSICS. VOLUME II. (Institute of Nuclear Physics, Krakow (Poland)). June 1967. 165p. Dep.

Sixteen lectures are included on particle and nuclear physics; separate abstracts are prepared for each. (L.B.S.)

For abstracts of individual papers see: 3309, 3378–3380, 3406–3409, 3452, 3453, and 3749–3754.

3290 CNEN'S FRASCATI NATIONAL LABORATORIES. THEORETICAL GROUP. Com. Naz. Energ. Nucl., Notiz., 13: No. 8-9, 107-8(Aug.-Sept. 1967). (In Italian).

This Group, established in 1960, has had since the inception a dual function: advisory and information to the Laboratories' experimental physicists, and independent theoretical research. (auth)

3291 THE COHERENT BEHAVIOR OF ELEMENTARY PARTICLES WITH BOSE AND FERMI STATISTICS. Ledinegg, E. (Technische Hochschule, Graz). Z. Phys., 205: 25-34(1967). (In German).

The coherent behavior of an electromagnetic field was described within the frame work of quantum electrodynamics by the correlation functions of nth degree introduced by Glauber. A coherence of the n_0^n is shown when the Glauber correlation function for $n \leq n_0$ can be factored. On the basis of this condition the known Poisson distribution for photons can be derived for the case of a completely coherent field. In this study the Glauber correlation functions were transferred to Fermi fields and their coherent behavior was investigated. It was shown that the correlation functions formed for Fermions of any degree cannot be factored so that there is no coherent Fermi field in this sense. It is shown however that uniform correlated Fermi particles which belong, according to this, to a noncoherent field possess a Poisson distribution. A Poisson distribution characterizes the completely coherent case only for bosons in the sense of the coherent definition used. (tr-auth)

3292 FAMILIES OF SUM RULES FROM CURRENT ALGEBRA. Amati, D. (CERN, Geneva, Univ., Trieste, Italy); Jengo, R.; Remiddi, E. Nuovo Cim. (10), 51A: 999-1020(Oct. 21, 1967).

By making use of a simple method different families of sum rules are obtained from current algebra. The method shows the relation of the reference frame in which equal-time commutators are considered with the form of the sum rules obtained and dispersion relations. The different contributions to the sum rules are then analyzed and it is recognized that besides the contributions which are generally considered, there are others which come from disconnected intermediate states, which play an important role. By discussing in detail the $P \rightarrow \infty$ sum rule the physical content of these extra terms and how they are responsible for the automatic cancellation of the singularities in the variables are shown which, due to the locality of equal-time commutators, do not appear in the right-hand side of the sum rules. The origin and value of these terms are purely dynamical, they have nothing to do with Schwinger terms and their presence is not related to convergence of the sum rule integrals. It is shown that the assumption that they vanish (so to recover the Fubini sum rule for the $P \rightarrow \infty$ family) implies superconvergence so that it appears clearly that superconvergence is a purely dynamical assumption and is not related to current algebra or locality of equal-time commutators. The structure of other families of sum rules is also discussed and, in particular, that corresponding to the "$\Delta \rightarrow \infty$" family which appears to be of particular interest. (auth)

3293 FUBINI SUM RULES FOR VERTEX FUNCTIONS. Halliday, I. G.; Landshoff, P. V. (Cambridge Univ., Eng.). Nuovo Cim. (10), 51A: 980-98(Oct. 21, 1967).

The method of Amati, Jengo and Remiddi for obtaining dispersion sum rules from current algebra is analysed in some detail, for the simple case of amplitudes connecting one particle and two currents. A simple perturbation-theory model provides a warning that the assumptions made in the derivation of the sum rules may not always be valid. When they are valid they may be used to give a derivation of the sum rules that is more direct than the one using current algebra. (auth)

3294 SUM RULES AND PERTURBATION THEORY. Halliday, I. G. (Cambridge Univ., Eng.). Nuovo Cim. (10), 51A: 970-9(Oct. 21, 1967).

The sum rules derived from current algebras are examined in a perturbative model to all orders. The Fubini and Taha sum rules are proved and the Amati–Jengo–Remiddi sum rule is proved for all graphs except the Born term. The existence of more complicated Schwinger terms is demonstrated. (auth)

3295 RELATIVISTIC WAVE EQUATIONS FOR ANY SPIN WITH OR WITHOUT MASS SPECTRUM. Hwa, R. C. (State Univ. of New York, Stony Brook). Nuovo Cim. (10), 51A: 1133-5(Oct. 21, 1967).

The formulation of a relativistic wave equation that is based on the Casimir operator whose eigenvalue specifies the spin of an elementary particle is investigated. It is pointed out that the wave equation proposed is the simplest way to build in ascending mass spectrum, and that even in the absence of a quantum field theory, its plane-wave solutions can be used to characterize a Hilbert space which may find applications in the saturation of current algebra or in the analytic S-matrix theory. (L.B.S.)

3296 EXAMPLE OF DYNAMICAL SYSTEMS WITH LINEAR TRAJECTORY. Ito, D. (Saitama Univ., Urawa, Japan); Mori, K.; Carriere, E. Nuovo Cim. (10), 51A: 1119-21(Oct. 21, 1967).

It is shown for a Dirac particle moving in a given external vector potential that the squared mass E^2 of the system is a linear function of the total angular momentum J and the quantum number n of the radial vibration. It is found that the harmonic-oscillator levels for $J = l + \frac{1}{2}$ and $J = l - \frac{1}{2}$ are widely separated by the strong spin-orbit coupling, and along each trajectory the parities of the successive states are alternating. These results suggest that the model is suitable as a starting point for developing models of particles and resonances. (L.B.S.)

3297 MODEL OF INTERACTION WITH DERIVATIVES ADMITTING AN EXACT SOLUTION. Medvedev, B. V. (Inst. of Mathematics, Moscow); Polivanov, M. K. Zh. Eksp. Teor. Fiz., 53: 1316-26(Oct. 1967). (In Russian).

A model is considered in which the interaction is of the form of a bilinear term containing derivatives. Such an interaction admits of an exact solution but then specific difficulties are encountered which are connected with the presence of the derivatives and which reduce to correctly taking into account the order of action of the differential operators in the complex expressions. (auth)

3298 GENERAL TREATMENT OF CURRENT ALGEBRA. Fubini, S. (Univ., Turin). Nuovo Cim. (10), 52A: 224-41 (Nov. 1, 1967).

A treatment of current algebra is proposed in which the fundamental identities are directly expressed as statements on the location and residues of fixed poles in the complex J-plane. The use of a representation of the scattering amplitude due to Khuri (which has a simple general relation with the original Regge representation) will give the most natural way of writing the identities. This new approach allows one to give a meaning to commutators whose corresponding sum rules had to be discarded because of the divergence of the dispersion integrals. (auth)

3299 SPECTRAL-FUNCTION SUM RULES AND FINITE-MESON-MASS CORRECTIONS. Albright, C. H.; Auvil, P. R.; Deshpande, N. G. (Northwestern Univ., Evanston, Ill.). Nuovo Cim. (10), 52A: 301-4(Nov. 1, 1967).

Two types of sum rules for the spectral functions associated with the propagators of vector and axial-vector currents were previously derived. These sum rules were used to obtain predictions for mass ratios and leptonic decay amplitudes. Since these calculations employ the soft-meson technique, the pseudoscalar-meson masses were set equal to zero before the two types of sum rules were applied in order to obtain convergent integrals. Corrections to these calculations due to finite meson masses are considered. (J.F.P.)

3300 GENERAL SUM RULES AND THE FORM OF THE EQUAL-TIME COMMUTATOR. Taha, M. O. (Univ. of Cambridge, Eng.). Phys. Rev., 162: 1694-1701(Oct. 25, 1967).

Using a method introduced in a previous paper, covariant functions corresponding to the retarded product and the equal-time commutator are defined. From these general sum-rule identities are obtained, employing three independent infinite limits. These identities considerably limit the form of the equal-time commutator. The simplest form consistent with the general covariance properties is discussed. (auth)

3301 EQUAL-TIME COMMUTATOR AND ZERO-ENERGY THEOREM IN THE LEE MODEL. Brandt, Richard A.; Orzalesi, Claudio A. (Univ. of Maryland, College Park). Phys. Rev., 162: 1747-50(Oct. 25, 1967).

A zero-energy theorem and its dependence on an equal-time commutation relation is considered for the Lee model. Contrary to a recent suggestion of Bell based on formal arguments, it is found that the noncanonical value of the commutator plays the significant role. The rigorous definition of equal-time commutators in more general cases is briefly discussed. (auth)

3302 CAUSALITY EFFECTS OF PARTICLES THAT TRAVEL FASTER THAN LIGHT. Newton, Roger G. (Indiana Univ., Bloomington). Phys. Rev., 162: 1274(Oct. 25, 1967).

Comments are made on a recent paper by Feinberg and an experiment is described in which an effect would precede its cause if there were particles that travel faster than light. (auth)

3303 HIGH ENERGY PHYSICS. VOLUME I. Burhop, E. H. S. (ed.). Pure and Applied Physics. A Series of Monographs and Textbooks. New York and London, Academic Press, 1967. 507p. $22.00; 176s.

Five articles are included in the first volume of a work that offers a comprehensive account of the entire field of contemporary high energy physics covering both theoretical and experimental aspects. Separate abstracts are prepared for each article. (L.B.S.)

For abstracts of individual sections see: 3304, 3326, 3427, 3458, and 3473.

3304 QUANTUM THEORY AND ELEMENTARY PARTICLES. Weisskopf, Victor F. (Massachusetts Inst. of Tech., Cambridge). pp 1-19 of High Energy Physics. Vol. I. Burhop, E. H. S. (ed.). New York and London, Academic Press, 1967.

A general introductory review is presented on the quantum theory of matter with specific consideration given to symmetry and dynamic properties of elementary-particle states. (L.B.S.)

3305 HIGH ENERGY PHYSICS. VOLUME II. Burhop, E. H. S. (ed.). Pure and Applied Physics. A Series of Monographs and Textbooks. New York and London, Academic Press, 1967. 492p. $24.00; 192s.

Six articles are included in Vol. II, which deals largely with high energy collision processes and includes authoritative accounts of the validity of quantum electrodynamics at high energy, and of neutrino and hypernuclear physics. Separate abstracts are prepared for each article. (L.B.S.)

For abstracts of individual sections see: 3354, 3371, 3372, 3461, 3462, and 3506.

3306 ELEMENTARY PARTICLE PHYSICS. 1966 Tokyo Summer Lectures in Theoretical Physics. Part II. Takeda, Gyo; Fujii, Akihiko (eds.). Tokyo, Syokabo Publishing Co. and New York, W. A. Benjamin, Inc., 1967. 215p.

Twelve lectures are included; separate abstracts are prepared for each. (L.B.S.)

For abstracts of individual papers see: 3307, 3351, 3352, 3367–3370, 3417, 3418, 3456, 3494, and 3538.

3307 PARTICLES AND SOURCES. Schwinger, Julian (Harvard Univ., Cambridge, Mass.). pp 193-209 of Elementary Particle Physics. Takeda, Gyo; Fujii, Akihiko (eds.). Tokyo, Syokabo Publishing Co. and New York, W. A. Benjamin, Inc., 1967.

It is proposed that the phenomenological theory of particles be based on the source concept, which is abstracted from the physical possibility of creating or annihilating any particle in a suitable collision. The source representation displays both the momentum and the space-time characteristics of particle behavior. Topics discussed include: spin and statistics, charge and the Euclidean postulate, massless particles, SU(3) and spin. It is emphasized that the source description is logically independent of hypotheses concerning the fundamental nature of particles. (auth)

Electromagnetic

Refer also to abstracts 2833, 3364, 3395, 3424, 3455, 3485, and 3583.

3308 (DESY-67/24) MONTE-CARLO-RECHNUNG FUER 3 GeV-SCHAUER IN BLEI. (Monte-Carlo Calculation for 3-GeV Showers in Lead). Burfeindt, H. (Physikalisches Staatsinstitut, Hamburg (West Germany). Hamburg Univ. (West Germany). II. Institut fuer Experimentalphysik). July 1967. 30p. (In German). Dep.

By means of a Monte Carlo program, parameters of electron-photon cascades in Pb were calculated for 3-GeV electrons as a primary particle. The results of the calculation were given in the form of energy, and longitudinal, radial, and angular distributions. (tr-auth)

3309 (INP-555/PL/PH, pp 113-15) SCATTERING OF VERY HIGH ENERGY PARTICLES FROM LIGHT NUCLEI. Czyz, W. (Institute of Nuclear Research, Krakow (Poland)).

An attempt is made to give a coherent interpretation of some recent experimental results on scattering of nucleons and electrons from nuclei. The interpretation is based on the Glauber model for the high energy multiple scattering of particles from complex targets. (L.B.S.)

3310 CROSSOVER AND POLARIZATION PHENOMENA IN HIGH-ENERGY SCATTERING. CUTS, CONSPIRACIES, AND SECONDARY REGGE POLES. Barger, V.; Durand III, L. (Univ. of Wisconsin, Madison). Phys. Rev. Lett., 19: 1295-8(Nov. 27, 1967).

The usual interpretation, in Regge-pole models, of the change in signs of the cross section differences $d\sigma(\bar{A}B)/dt - d\sigma(AB)/dt$ at $t \sim -0.15$ $(GeV/c)^2$ observed in elastic πN, KN, and NN scattering is inconsistent with recent data on the reaction $\gamma p \to \pi^0 p$. It is pointed out that this contradiction is direct evidence for the existence of contributions to the high-energy scattering amplitudes in addition to those of the leading Regge poles. Alternative explanations of the crossover phenomena which avoid the foregoing difficulty are proposed, and their implications are discussed. (auth)

3311 QUASI-CLASSICAL PURE GYROSCOPE. Rafanelli, K. (Queens Coll., Flushing, N. Y.). Nuovo Cim. (10), 52A: 342-50 (Nov. 21, 1967).

The classical relativistic theory of the pure gyroscope is used as a model for the quasi-classical description of a spinning electron. Traditional WKB quantization requirements show that the constructed wave functions are asymptotic solutions of the first-order Dirac equation and that the eigenvalues of the first-order Dirac theory are reproduced in the cases tested. (auth)

3312 EFFECT OF ELECTROMAGNETIC INTERACTION FOR $K^+ \to \pi^+\pi^0$ DECAY. Watanabe, K. (Dublin Inst. for Advanced Studies). Nuovo Cim. (10), 52A: 519-28(Nov. 21, 1967).

Dashen and Frautschi's method for the proton and the neutron mass difference is extended to $K \to 2\pi$ decay process. The possible enhancement of the electromagnetic interaction for $K^+ \to \pi^+\pi^0$ decay is discussed by using κ-model. (auth)

3313 ANGULAR DISTRIBUTION IN PION ELECTROPRODUCTION. Zagury, N. (Harvard Univ., Cambridge, Mass.). Nuovo Cim. (10), 52A: 506-18(Nov. 21, 1967).

The angular distribution of pions in electroproduction is calculated and its dependence on the pion form factor and the neutron charge form factor is studied. (auth)

3314 ON THE FOLDY-WOUTHUYSEN TRANSFORMATION FOR PARTICLES IN AN ELECTROMAGNETIC FIELD. Garrido, L. M.; Oliver, L. (Univ., Barcelona). Nuovo Cim. (10), 52A: 588-605(Nov. 21, 1967).

An extent of the Foldy–Wouthuysen transformation to particles of arbitrary spin interacting with an electromagnetic field is presented. Equations are derived for particles of spin $\frac{1}{2}$, 0 and 1 interacting with the electromagnetic field in the nonrelativistic limit; also, the operators associated with the dynamical variables mean position and mean velocity, in the new and old representations are calculated interpreting physically the terms of the obtained Hamiltonian. In particular it is noticed that the formulation solves a remaining problem in obtaining a Darwin term analogous for spin $\frac{1}{2}$, 0 and 1. This formulation is based on the Foldy–Wouthuysen transformation for spin-$\frac{1}{2}$ particles in an electromagnetic field, and on a generalization for arbitrary spin of the Foldy–Wouthuysen transformation previously presented. (auth)

3315 ON SINGH'S LEMMA FOR LOW-ENERGY COMPTON SCATTERING. Bell, J. S. (CERN, Geneva). Nuovo Cim. (10), 52A: 635-6(Nov. 21, 1967).

A derivation is given for a lemma of Singh which proved useful in establishing low-energy theorems for Compton scattering. The original treatment dependence on the validity of a certain infinite expansion over intermediate states can be avoided. The result follows essentially from gauge invariance and the notion that the amplitude, after extraction of the pole terms, is a smooth function. (J.F.P.)

3316 PHOTONS, MESONS, AND FORM FACTORS. Schwinger, Julian (Harvard Univ., Cambridge, Mass.). Phys. Rev. Lett., 19: 1154-7(Nov. 6, 1967).

The necessity of a form factor to connect the photon with ξ^0, ω, and ϕ for interpreting the electromagnetic effects of strongly interacting particles is discussed. (L.B.S.)

3317 SEARCH FOR RARE ETA DECAY MODES: C-NON-CONSERVING DECAY $e^+e^-\pi^0$; DALITZ DECAY $e^+e^-\gamma$. Bazin, M. (Princeton Univ., N. J.); Goshaw, A. T.; Zacher, R.; Blumenfeld, H.; Kitagaki, T.; Sun, C. R. Phys. Rev. Lett., 19: 1157-9(Nov. 6, 1967).

A deuterium bubble-chamber experiment was performed which gives an upper limit of 0.13% for the branching ratio $(\eta \to e^+ + e^- + \pi^0)/(\eta \to \text{all modes})$ and indicates agreement with an ordinary Dalitz decay for $\eta \to e^+ + e^- + \gamma$. (auth)

3318 ELECTRIC AND MAGNETIC POLARIZABILITIES OF MESONS AND BARYONS IN QUARK MODEL. Zaikov, R. P. (Joint Inst. for Nuclear Research, Dubna, USSR). Acta Phys. Pol., 32: 495-500(1967).

The nonrelativistic quark model is used to obtain the coefficients for the electric and magnetic polarizabilities of baryons and mesons. Some theoretical numerical estimations are given for the magnetic polarizabilities. (auth)

3319 PHOTOPRODUCTION OF BOSONS ON NUCLEI WITH S = T = 0. Mel'nikov, V. N.; Nikitin, Yu. P. JETP Lett. (USSR) (Engl. Transl.), 6: 52-4(July 15, 1967).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu, 6: 528-30(July 15, 1967).

The characteristics of processes of the type $\gamma + Z \to a + Z$, where a is a boson resonance with $|S| = 0$, (without excitation of a nucleus with S = T = 0) which can be predicted on the basis of parity and charge parity conservation, relativistic invariance, and the Regge pole model. It is found that in coherent photoproduction of boson resonances on nuclei, the angular distribution is much simpler than in photoproduction of nucleons. (J.F.P.)

3320 THE INFRA-RED RADIATIVE CORRECTIONS FOR COLLIDING BEAM (ELECTRONS AND POSITRONS) EXPERIMENTS. Etim, E.; Pancheri, G.; Touschek, B. (CNEN, Frascati, Italy). Nuovo Cim. (10), 51B: 276-302(Oct. 11, 1967).

The infra-red corrections to be applied to the results expected from an electron positron colliding beam experiment are determined with the help of the Bloch-Nordsieck theorem. Experiments are characterized by a resolution function $\rho(k)$ of a four-dimensional timelike energy-momentum vector, which represents the probability that a four-momentum loss k escapes detection. The results are applicable to a class of experiments in which the statistical error is matched to the error of the energy-momentum resolution. Various approximations which allow a rapid and accurate estimate of radiative corrections are discussed. (auth)

3321 POLARIZATION CHARACTERISTICS OF MUONS IN PROCESSES OF REVERSE μ-e DECAY. Shyshkin, G. V. Vestsi Akad. Navuk BSSR, Ser. Fiz.-Mat. Navuk, No. 2, 76-82(1966). (In Russian).

A two-component neutrino theory is used for processes of reverse μ-e decay. Differences resulting in muon polarization characteristics are discussed. Also the cross sections for the studied processes depending on the Hamiltonian applied and the neutrino model used are considered. (J.F.P.)

3322 SIDEWISE DISPERSION RELATIONS AND SOME RELATIONS AMONG MAGNETIC MOMENTS. Muta, T. (Kyoto Univ.). Nuovo Cim. (10), 51A: 1154-7(Oct. 21, 1967).

Some relations among magnetic moments of hadrons are derived using the sidewise dispersion relations for some vertex functions. As a typical example the magnetic moment of the Roper resonance with $I = J = \frac{1}{2}$ at a mass of 1400 MeV is discussed, which is found in the P_{11} channel of π-N scattering. (L.B.S.)

3323 THE γNN^* COUPLING FROM CURRENT ALGEBRA. Barnes, K. J.; Williams, R. M. (Imperial Coll., London). Nucl. Phys., B3: 424-34(1967).

The γNN^* (1238) coupling is calculated (to 17%) from a saturation at infinite momentum of the algebra of isospin current densities. In recognition of the fact that no naive saturation is sufficient, parametric transitions are introduced from the states of the saturation to neglected ones, and these parameters are then evaluated by utilizing the detailed knowledge of nucleon electromagnetic form factors. (auth)

3324 A REGGE POLE MODEL FIT OF PION AND K MESON PHOTOPRODUCTION. Ader, J. P. (CERN, Geneva); Capdeville, M.; Salin, Ph. Nucl. Phys., B3: 407-23(1967).

Differential cross sections in the forward direction for π^+, π^0, and K^+ photoproduction are evaluated with Regge trajectories exchange in the t-channel. Kinematical singularities, constraints among helicity amplitudes, conspiracy and evasion were studied very carefully. A very good fit is obtained for $\gamma p \to \pi^0 p$, assuming ω and B exchange and with only three parameters, for $2 \leq E_\gamma \leq 5$ GeV and transfer momentum t up to -3 (GeV/c)^2. Good agreement is also observed for $\gamma p \to \pi^+ n$ with π and B exchange, and for $\gamma p \to \Lambda^0 K^+$ and $\gamma p \to \Sigma^0 K^+$ with K and K^* exchange. Present experimental data seem to exhibit violations of the SU_3 symmetry. (auth)

3325 POLE TERMS IN THE FIXED ANGLE APPROACH TO PHOTOPRODUCTION OF PIONS ON NUCLEONS. Jurewicz, A. (Univ., Rome). Z. Phys., 4: 393-403(1967).

The properties of well known pole contributions to photoproduction amplitudes are studied but in the space of cm three-momentum squared and scattering angle. Some conclusions essential to the fixed angle approach are drawn. Also some results of more general character are given. These are plots and numerical tables of pole contributions to multipole amplitudes. (auth)

3326 ELECTROMAGNETIC FORM FACTORS. Griffy, T. A.; Schiff, L. I. (Stanford Univ., Calif.). pp 341-90 of High Energy Physics. Vol. I. Burhop, E. H. S. (ed.). New York and London, Academic Press, 1967.

A brief introduction is given of scattering processes for studying electromagnetic form factors. Section II develops the theory that is needed to extract the form factors from the elastic electron–nucleon scattering cross sections and discusses the limitations of the first-order analysis. The relation between nucleon form factors and the scattering from hydrogen, deuterium, tritium, and ^{3}He is discussed in Section III. The interpretation of form factors in terms of spectral representations and multi-

pion resonances is considered in Section IV, and Section V deals with pion production by electron impact and the determination of the pion form factor. (100 references) (L.B.S.)

3327 CURRENT ALGEBRA, WEINBERG SUM RULES, AND THE $K^+ - K^0$ MASS DIFFERENCE. Early, C.; Bose, S. K. (Univ. of Notre Dame, Ind.). Nuovo Cim. (10), 52A: 305-7(Nov. 1, 1967).

The current algebra method is used to explain the $K^+ - K^0$ mass difference. It is found that this method also leads to a wrong sign for the mass difference. The details of the calculation are given. (J.F.P.)

3328 ON THE SOLUTION OF DISPERSION RELATIONS FOR THE PHOTOPRODUCTION AND ELECTROPRODUCTION OF THE $T = J = 3/2$ ISOBAR. Selleri, F. (Univ., Bologna. Istituto Nazionale di Fisica Nucleare, Bologna); Grecchi, V.; Turchetti, G. Nuovo Cim. (10), 52A: 314-18(Nov. 1, 1967).

It is pointed out that all previous difficulties in the problem of finding an explicit solution for multipoles leading to the resonant $T = J = 3/2$ state can be circumvented and that an explicit relativistic solution can be given. The result is $M_1 + (\omega) = M_{1+}$ (ω, relativistic)/f^B_{33} (ω, relativistic)} f_{33} (ω). A very similar result is also obtained for the electroproduction case. (J.F.P.)

3329 CALCULATION OF THE DECAY RATE OF $K^0_2 \to \pi^+ + \pi^- + \gamma$. Lai, C. S.; Young, B. L. (Indiana Univ., Bloomington). Nuovo Cim. (10), 52A: 83-90(Nov. 1, 1967).

In $K^0_2 \to \pi^+ + \pi^- + \gamma$, the decay can go either through a direct process or through an inner bremsstrahlung process. By applying the method of current algebras the branching ratio of the direct CP-conserving process with the decay $K_2 \to 2\gamma$ is estimated. The result is $R_1(K^0_2 \to \pi^+\pi^-\gamma)/R(K^0_2 \to 2\gamma) \simeq 14\%$. The inner bremsstrahlung term accompanying the CP-violation process $K^0_2 \to \pi^+ + \pi^-$ is also calculated. We obtain for the latter the results $R_2(K^0_2 \to \pi^+\pi^-\gamma)/R(K^0_2 \to \pi^+ + \pi^-) = 1.1\%$, for $E \geq 10$ MeV, 0.26%, for $E \geq 50$ MeV, where E_γ is the energy of the photon emitted in the process $K^0_2 \to \pi^+ + \pi^- + \gamma$. Using the recent experimental data on the decay rates of $K^0_2 \to 2\gamma$ and $K^0_2 \to \pi^+ + \pi^-$, we obtain the total rate $R(K^0_2 \to \pi^+\pi^-\gamma) \simeq (2.1 \pm 0.4) \cdot 10^3\ s^{-1}$, for $E \geq 10$ MeV. (auth)

3330 THREE-PION MODES OF THE η-MESON. Clavelli, L. (Univ. of Chicago). Nuovo Cim. (10), 52A: 73-82(Nov. 1, 1967).

The $\eta_{3\pi}$ amplitudes are investigated in various soft-meson limits using an effective Hamiltonian of the standard current-current form. A simple dynamical model is constructed that reproduces all the zero-energy limits of the current algebra. The suppression of the $3\pi^0$ mode is predicted and the deviation from phase-space of the charged mode is given in moderate agreement with experiment. (auth)

3331 GREEN FUNCTION AND MOBILITY OF AN ELECTRON IN A RANDOM POTENTIAL. Chaplik, A. V. (Inst. of Physics of Semiconductors, Novosibirsk, USSR). Zh. Eksp. Teor. Fiz., 53: 1371-7(Oct. 1967). (In Russian).

The Green function of an electron in a random potential obeying the normal distribution is calculated. The form of the wave function suggested by Feynman is employed. It was possible to find the Green function by taking into account a uniform electric field and not assuming smallness of the latter. (auth)

3332 CURRENT ALGEBRAS, REGGE POLES, AND THE ISOVECTOR ANOMALOUS MAGNETIC MOMENT OF THE NUCLEON. Goldberg, Hyman; Gross, Franz (Cornell Univ., Ithaca, N. Y.). Phys. Rev., 162: 1350-8(Oct. 25, 1967).

The sum is discussed for the isovector anomalous magnetic moment of the nucleon $F^V_2(0) = 1.85$, which is obtained from the current commutation relation $\delta(x_0)[A^+_\lambda(x), A^-_\nu(0)] = 2V^\lambda_3(x)\delta^4(x)$ by use of the covariant method proposed by Fubini. It is found that (1) the sum rule cannot be evaluated without explicit knowledge of one of the axial-vector–nucleon "scattering" amplitudes; (2) calculating the contributions from the $P_{33}(1236)$ and $D_{13}(1525)$ using a dispersion-pole model of the weak amplitude gives only $F^V_2(0) = 0.37$, and (3) estimating the high-energy continuum contribution to the sum rule from Regge-pole fits to πp charge-exchange scattering increases the result to $F^V_2(0) \cong 1.0$. It seems that the sum rule is dominated by low- and high-energy continuum contributions, which must be more accurately known before the validity of the sum rule can be judged. (auth)

3333 DRELL-HEARN-GERASIMOV SUM RULE: EXAMPLES AND COUNTEREXAMPLES. Barton, G. (Univ. of Sussex, Eng.); Dombey, Norman. Phys. Rev., 162: 1520-5(Oct. 25, 1967).

It is investigated by means of examples whether the Drell–Hearn–Gerasimov sum rule can hold simultaneously for a lightly bound state and for its constituents. Subject to certain assumptions, whose applicability is discussed, it is found in particular that if the rule holds for the nucleons, then it holds for the deuteron but fails for ^{3}He and ^{3}H. If neutron and proton masses were appreciably unequal, then the rule would fail for the deuteron as well. (auth)

3334 MODEL FOR ELECTRON EXCITATION OF THE NUCLEON. Walecka, J. D. (Stanford Univ., Calif.). Phys. Rev., 162: 1462-78(Oct. 25, 1967).

A very crude model of oscillations of the meson field in the nucleon is made which gives an excitation spectrum similar to that of the nucleon and which allows calculation of the transition form factors for the allowed normal-parity Coulomb transitions $1/2^+ \to 3/2^-$, $5/2^+$, $7/2^-$, etc. The results are compared with the recent Cambridge Electron Accelerator (CEA) data, and predictions, applicable to the planned Stanford Linear Accelerator (SLAC) experiments, are made for the other relevant isobars and other momentum transfers. (auth)

3335 COMPLEX SCATTERING AMPLITUDES IN ELASTIC ELECTRON SCATTERING. Zeitler, Elmar (Armed Forces Inst. of Pathology, Washington, D. C.); Olsen, Haakon. Phys. Rev., 162: 1439-47(Oct. 25, 1967).

The scattering amplitudes derived from the Molière approximation are compared with those derived from the first- and second-order Born approximations. A numerical analysis applying a Thomas–Fermi potential was performed. In certain ranges of $a = Z/137\beta$ and the scattering angle, the first-order Born approximation rendered amplitudes that can be applied for the more exact modulus of the Molière approximation, and the second-order Born approximation rendered phases of the scattering amplitudes that are comparable with those obtained by the Molière approximation. (auth)

3336 O(4) SYMMETRY AND THE FORWARD PHOTOPRODUCTION OF PIONS AT HIGH ENERGIES. Mitter, P. K. (Univ. of California, Santa Barbara). Phys. Rev., 162: 1624-7(Oct. 25, 1967).

Forward photoproduction of pions is studied at high energies with the use of O(4) symmetry. It is shown that, in this limit, the asymptotic contribution to the amplitude comes from a unique conspiring family of Regge poles of a definite O(4) class. The use of O(4) symmetry in the presence of unequal masses ($\gamma N \to \pi N$) is commented on. (auth)

3337 EXTRAPOLATION OF NUCLEON FORM FACTORS. II. Levinger, J. S. (Rensselaer Polytechnic Inst., Troy, N. Y.). Phys. Rev., 162: 1589-1603(Oct. 25, 1967).

The magnetic isoscalar form factor is fitted with two poles: the ω and the ϕ resonance. The magnetic isovector form factor G_{MV} for spacelike and timelike momentum transfers is fitted using the conformal-transformation techniques of Levinger, Peierls, and Wang, and these techniques are tested using artificial data. If a contribution is not assumed from the ρ resonance, a spectral function is found with a broad peak some 100 MeV below the position of the ρ, and with a negative dip around 1200 MeV. If it is assumed that the ρ resonance contributes additively at its known position and width, but with an adjustable coefficient for its strength, it is argued that the ρ contributes about 90% of the static moment. The complete spectral function shows a shoulder around 500 MeV, and again a negative dip around 1200 MeV. If it is assumed that G_{MV} is a product of the form factor for the ρ and an adjustable function, it is found that the spectral function has a high peak near the ρ resonance, and a marked negative dip at 900 MeV. The ρ again contributes some 90% of the static moment. The different phenomenonological fits are in semiquantitative agreement with each other and with the recent field-theoretical calculations of Furuichi et al. (auth)

3338 UNITARITY OF THE S MATRIX AND ANALYSIS OF THE $\gamma + p \to \eta + p$ REACTION AT LOW ENERGY. Minami, Shigeo (Osaka City Univ., Japan). Phys. Rev., 162: 1619-23 (Oct. 25, 1967).

The amplitudes for the $\gamma + p \to \eta + p$ reaction are discussed, taking the unitarity condition on the S matrix into consideration. It is shown that the experimental results for the reaction from threshold to about 970 MeV can be explained fairly well in terms of the reaction amplitudes due to the S_{11} and $D_{13}(1518)$ resonances. Moreover, the polarization of recoil protons in the reaction is predicted with the ($S_{11} + D_{13}$) model. On the basis of the results, it is emphasized that polarization measurement is one of the best means to examine the contribution to the reaction from the $D_{13}(1518)$ resonance at the energy corresponding to the observed peak of $\sigma(\gamma + p \to \eta + p)$ or $\sigma(\pi^- + p \to \eta + n)$. (auth)

3339 PION ELECTROMAGNETIC FORM FACTOR FROM COULOMB INTERFERENCE. West, Geoffrey B. (Cornell Univ., Ithaca, N. Y. Stanford Univ., Calif.). Phys. Rev., 162: 1677-82(Oct. 25, 1967).

Using recent 24-MeV $\pi^\pm$-α elastic scattering data the Hof-

stadter–Sternheim proposal for measuring the pion electromagnetic form factor is critically analyzed. A phenomenological nonlocal potential, whose parameters are fixed directly from the data, is used to describe the nuclear interaction. Using these parameters, a type of distorted-wave Born approximation is then employed to calculate the Coulomb contributions. It is concluded that (i) nuclear distortion effects on the Coulomb contribution are large; (ii) the fits are not very sensitive to the pion radius and from the data only a conservative upper limit of ~1.5 F can be reasonably given; (iii) experimental statistics need to be greatly improved before a more definitive result can be obtained; (iv) sensitivity to the model parameters seems to be smallest in the region of backward scattering ($\theta_{lab} \gtrsim 100^\circ$), where sensitivity to the pion radius is greatest; and (v) the fruitfulness of going to much higher energies (>100 MeV) is probably quite limited. Some suggestions for present and future experimental and theoretical work are briefly discussed. (auth)

3340 C-CONSERVING DECAY $\eta \to \pi^0 e^+ e^-$ IN A VECTOR-MESON-DOMINANT MODEL. Cheng, T. P. (Rockefeller Univ., New York). Phys. Rev., 162: 1734-8(Oct. 25, 1967).

The decay $\eta \to \pi e^+ e^-$ through a C-conserving, two-photon intermediate state is studied in a vector-meson-dominant model. The branching ratio $\Gamma(\eta \to \pi e^+ e^-)/\Gamma(\eta \to \pi\gamma\gamma)$ is found to be $\approx 10^{-5}$. If, in addition, a quark model is assumed for the photon–pseudoscalar–vector-meson vertex, a value of 1.3×10^{-3} eV is obtained for the decay width of $\eta \to \pi e^+ e^-$. General features of the decay spectrum with respect to the sum and difference of the electron and positron energies in the η rest frame are discussed. (auth)

3341 DOUBLE-COINCIDENCE TRIDENT EXPERIMENTS. Ehn, D. C.; Henry, G. R. (Harvard Univ., Cambridge, Mass.). Phys. Rev., 162: 1722-8(Oct. 25, 1967).

Some general features of trident production (electroproduction of a lepton pair) are discussed, and numerical calculations are given for double-coincidence trident cross sections (where two of the three final leptons are detected). The calculations suggest that double-coincidence trident experiments may be done with equipment and counting rates rather similar to those of experiments on the photoproduction of wide-angle lepton pairs. (auth)

3342 MODEL FOR THE ELECTRIC DIPOLE MOMENT OF THE NEUTRON. Babu, P.; Suzuki, Mahiko (California Inst. of Tech., Pasadena). Contract AT(11-1)-68. Phys. Rev., 162: 1359-61(Oct. 25, 1967). (CALT-68-129).

A model of the electric dipole moment of the neutron is proposed and evaluated with the help of current algebra and the hypothesis of partially conserved axial-vector current. (auth)

3343 INELASTIC ELECTRON SCATTERING FROM HYDROGEN. Lynch, Harvey Lee. Stanford, Calif., Stanford Univ., 1966. 127p.

Thesis.

A large body of data on inelastic electron scattering from hydrogen is presented in two groups. One group consists of data at fixed momentum transfer, q, and fixed secondary energy with the energy loss as a variable. These data are taken for q^2 ranging from 0.1 to 0.6 in steps of 0.1 $(BeV/c)^2$ and secondary energies of 100, 150, 200, and 400 MeV; they concentrate on production of the first pion-nucleon resonance, although some data extending out to the second resonance are also presented. The other group of data is taken at constant momentum transfer and constant equivalent photon energy, K; q^2 ranges from 0.1 to 0.6 in steps of 0.1 $(BeV/c)^2$ and K is 340 (first resonance) and 500 MeV. These data are designed to separate the contribution of transversely and longitudinally polarized photons to the inelastic cross section. The transverse part, σ_t, is found to be dominant, but the longitudinal part, σ_s, is not zero at resonance but zero above resonance. A simple scaling law for the transverse part is found, viz., $\sigma_t \propto \tilde{q}^{*2}\, G^2_{MP}$, where $\tilde{q}^*$ is the space part of the momentum transfer in the center of mass frame of the final pion-nucleon system. This scaling appears to hold for a broad range of equivalent photon energies. Theoretical uncertainties prohibit the extraction of information on the electric form factor of the neutron. (Disser. Abstr.)

3344 RARE DECAY MODES OF THE η MESON. Young, Bing-lin. Minneapolis, Univ. of Minnesota, 1966. 173p.

Thesis.

The rare decay modes of the η-meson to be considered are the Dalitz pair decay modes, $\eta \to l^+l^-\gamma$, and the direct modes $\eta \to l^+l^-$, with l representing an electron or a muon. To the lowest order in the electromagnetic interaction, and to all orders in strong interactions, these decays are related to $\eta\rho\gamma$ vertex function $\Gamma_\eta(k_1^2, k_2^2)$. Since unitary sets a lower bounds for the direct decays which are not zero, $\Gamma_\eta(k_1^2, k_2^2)$ must possess a nontrivial structure. A model is used to evaluate this form factor. In the model, the low energy and the high energy behaviors are separately considered. (TSS) (Disser. Abstr.)

3345 MESONS IN SINGULAR POTENTIALS. Fritz, Karl Johnston. Columbia, S. C., Univ. of South Carolina, 1965. 96p.

Thesis.

The wave functions describing certain angular momentum states of a charged point vector meson interacting with a c-number Coulomb potential have well known essential singularities at the origin. Furthermore, this set of wave functions is known to be over complete. If the meson is given a nonzero size of a reasonable type, the interaction near the origin is modified sufficiently to reduce the number of solutions which are physically acceptable from three to two which are analytic. Such a modification in potential occurs if the vector meson in a bound state is treated nonrelativistically and the meson's charge is coupled to the zero point fluctuations in in the quantized transverse electromagnetic field. A method for making numerical approximations to the wave functions and energy levels is presented and a detailed example of the technique is given for the simple case of a Schroedinger particle constrained to one dimensional motion between two hard barriers. The numerical computations indicate that the vector meson energy levels do not differ markedly from those of a Schroedinger particle. This result is in agreement with a variational calculation of Case and Messiah. Some analogous calculations are presented for the scalar meson bound in a strong Coulomb potential where, as is well known, there are enough physically acceptable wave functions that no conditions need to be placed on the energy to afford proper behavior for large r. (Disser. Abstr.)

3346 ELEKTROMAGNITNAYA STRUKTURA YADER I NUKLONOV. (Electromagnetic Structure of Nuclei and Nucleons). Fedyanin, V. K. Moscow, Izdatel'stvo Vysshaya Shkola, 1967. 176p.

New data on the electromagnetic structure of nuclei and nucleons appearing in domestic and foreign literature up to the beginning of 1966 are compiled. The distribution of electric and nuclear charge in nuclei, nucleon form factors, form factors of two- and three-nucleon systems, and the Compton effect on nucleons are discussed. (C.E.S.)

Weak

Refer also to abstracts 2845, 3321, and 3395.

3347 (UCRL-17781) DECAY PARAMETERS FOR $\Sigma^\pm \to n\pi^\pm$. Bangerter, Roger O.; Alston-Garnjost, Margaret; Barbaro-Galtieri, Angela; Gershwin, Lawrence K.; Mast, Terry S.; Solmitz, Frank T.; Stevenson, M. Lynn; Tripp, Robert D.; Verglas, Alain J.; Webber, Bryan R. (California Univ., Berkeley. Lawrence Radiation Lab.). Aug. 25, 1967. Contract W-7405-eng-48. 8p. (CONF-670934-8). Dep. CFSTI.

From International Conference on Elementary Particles, Heidelberg, Germany.

Measurements of the decay parameters β_i and γ_i for $\Sigma^\pm \to n + \pi^\pm$ are presented. It is confirmed that the $\Sigma^+ \to n + \pi^+$ decay takes place predominantly in the P wave, and found that $\Sigma^- \to n + \pi^-$ is dominated by S-wave decay, in agreement with the $\Delta I = 1/2$ rule. The experiment was performed at the Bevatron using the 25-inch hydrogen bubble chamber. More than 10^5 charged Σ hyperons produced by $K^- + p$ interactions at an average momentum of 385 MeV/c were analyzed. (J.F.P.)

3348 WEAK ANNIHILATION OF ELECTRON–POSITRON PAIR. Guliev, N.; Rustamova, A. Izv. Akad. Nauk Azerb. SSR, Ser. Fiz.-Tekh. Mat. Nauk, No. 2, 98-100(1966). (In Russian).

Weak annihilations $e^+ + e^- \to \nu + \bar{\nu}$ were studied using intermediate vector mesons in order to determine the peculiar behavior of the cross sections at high energies. The calculations were made assuming that the weak interactions are transmitted by changed and neutral mesons (though their presence is doubtful) and assuming for the neutrino the presence of a charged form-factor induced by various virtual processes. (R.V.J.)

3349 ISOTOPIC-SPIN ANALYSIS OF POSSIBLE CP-VIOLATING EFFECTS IN $K \to 3\pi$. Gaillard, M. K. (Laboratoire de Physique Theorique et Hautes Energies, Orsay, France). Nuovo Cim. (10), 52A: 359-72(Nov. 21, 1967).

CP-violating effects in the decay $K \to 3\pi$ are analyzed in terms of isotopic-spin parameters. In particular, the interference term between K_S and K_L amplitudes, and the difference in partial rates in $K^\pm$ decay are considered. In general, the real part of the interference term is expected to be much smaller than the imaginary part for transitions with $|\Delta I| < 1/2$. The success of the $|\Delta I| = 1/2$ rule in K_L- and K^+-decay sets an upper limit on the imaginary part of

the interference term for CP-violating amplitudes with $|\Delta I| = \frac{1}{2}$. This limit is probably too high to be useful, but a significant effect in the real part would probably indicate that amplitudes with $|\Delta I| > \frac{1}{2}$ are important. This conclusion could be checked by comparing the real part of the interference term with the differences in partial rates in K^2 decay; the two effects are directly related through coefficients depending on $|\Delta I|$ and the isotopic spin of the final state. In K^0 decay, I = 1 final states ($|\Delta I| < \frac{3}{2}$) may be distinguished from I = 3 final states ($|\Delta I| \geq \frac{3}{2}$) by comparing the imaginary parts of the interference terms in the $\pi^+\pi^-\pi^0$ and the $3\pi^0$ modes. (auth)

3350 ASYMPTOTIC SYMMETRY AND FORM FACTORS. Zee, A. (Univ. of California, La Jolla, Harvard Univ., Cambridge, Mass.). Nuovo Cim. (10), 52A: 628-30(Nov. 21, 1967).

A discussion of asymptotic symmetry and form factors is considered for the decays $A_1 \rightarrow \rho + \pi$ and $K_A \rightarrow K^* + \pi$. The ratio of the widths for these two decays is predicted to be 0.8. (J.F.P.)

3351 ELEMENTARY-PARTICLE THEORY OF NUCLEAR BETA DECAY AND MUON CAPTURE. Primakoff, Henry (Laboratoire de Physique Theorique et Hautes Energies, Orsay, France). pp 168-92 of Elementary Particle Physics. Takeda, Gyo; Fujii, Akihiko (eds.). Tokyo, Syokabo Publishing Co. and New York, W. A. Benjamin, Inc., 1967.

The weak interaction of nuclei are treated without any explicit consideration of the nuclei as composed on nucleons; rather the weak interaction matrix elements between the initial and final nuclear states involved are described in terms of form factors characteristic of the nuclei as wholes, the numerical values of these form factors (at the relevant momentum transfers) reflecting the complexity of the internal nuclear structure. The advantages of this approach are pointed out. Three particular cases are considered: nuclear beta decay; nuclear muon capture; and sum rules in nuclear beta decay. (L.B.S.)

3352 STANDING PROBLEMS IN WEAK INTERACTIONS AND CP-VIOLATION. Michel, Louis (Institut des Hautes Etudes Scientifiques, Bures-sur-Yvette, France). pp 161-7 of Elementary Particle Physics. Takeda, Gyo; Fujii, Akihiko (eds.). Tokyo, Syokabo Publishing Co. and New York, W. A. Benjamin, Inc., 1967.

A brief discussion is presented, including some speculations, on each of the following problems of the weak interaction: structure at short distance; Cabibbo angle, $\Delta I = \frac{1}{2}$ rule; neutral leptonic currents; lepton conservation, μ-e symmetry; and CP violation. (L.B.S.)

3353 RADIATIVE CORRECTIONS TO THE NON-LEPTONIC Σ DECAYS AND THE $\Delta I = \frac{1}{2}$ RULE. Jarlskog, C. (Univ. of Lund, Sweden). Nucl. Phys., B3: 365-79(1967).

The influence of radiative corrections on the decay parameters of the non-leptonic Σ decays are estimated with the aid of standard perturbation theory, treating all particles as point particles. The result is divergent (except in one special case) but can be handled with the aid of a cut-off. Assuming T-invariance and the $\Delta I = \frac{1}{2}$ rule, the decay parameters are then calculated using the three partial decay rates and the parameter α^- as input data. The result is rather insensitive to the radiative corrections except for the parameter α^+. The agreement between the calculation and the experimental data is good for the parameter α^0 but for α^+ a discrepancy of about two standard deviations appears to exist. Without radiative corrections, the corresponding discrepancy is about three standard deviations. No accurate measurements on the remaining parameters are as yet available. (auth)

3354 NEUTRINO PHYSICS. Lederman, Leon M. (Columbia Univ., New York). pp 303-64 of High Energy Physics. Vol. II. Burhop, E. H. S. (ed.). New York and London, Academic Press, 1967.

A historical account is given of developments that led to the field of neutrino physics. Theoretical predictions are first considered; the reactions that can be observed using neutrino beams and the cross sections calculated using the usual weak interaction theory are listed. A description is given of high energy neutrino experiments, including the BNL, CERN, and ANL arrangements. Calculations and various attempts to observe the flux of high energy neutrinos from the decay of pions and kaons generated in the atmosphere by cosmic ray primaries are reported. Experimental results from accelerators are reported on two neutrinos, "neutrino flip" hypothesis, conservation of leptons, neutral currents, elastic and inelastic scattering, the search for intermediate boson, and antineutrinos. The experimental outlook for the study of weak interactions is discussed. (140 references). (L.B.S.)

3355 APPLICATION OF CURRENT ALGEBRAS TO NON-LEPTONIC HYPERON DECAYS. Mohanti, A. K. (Univ. of Rochester, N. Y.). Nuovo Cim. (10), 52A: 1-6 (Nov. 1, 1967).

Current algebras applied to nonleptonic hyperon decays lead to p-wave amplitudes of about one-half of the experimental values and to worse values of $B(\Sigma^\pm)$. With new experimental data the results of Brown and Sommerfield become worse for p-wave amplitudes, in particular for $B(\Sigma^\pm)$. An attempt is made to correct this situation by taking into account the SU_3-breaking effect in estimating the equal-time commutator term for p-waves from the $K_1^0 \rightarrow 2\pi$ decay amplitude which is also SU_3-violating. Fits to both s and p-waves are made without assuming SU_3. The results are somewhat improved. (auth)

3356 APPLICATION OF CURRENT COMMUNICATION RULES TO NONLEPTONIC DECAYS. Nataf, R. (Institut de Physique Nucleaire, Orsay, France). Nuovo Cim. (10), 52A: 7-22(Nov. 1, 1967).

Current algebra was previously applied to nonleptonic decays. Reviewing the derivations given the work was hindered for a time by the apparent difficulty of the surface terms connected with the use of the reduction formula. A pedestrian derivation showing that they must be taken as vanishing is given. The zero-momentum approximation in the formulation is briefly discussed, and no better justification for it is found. (auth)

3357 PHENOMENOLOGICAL ANALYSIS OF $K \rightarrow \pi\pi(I = 2)$ AMPLITUDES AND VIOLATION OF CP INVARIANCE. Martin, B. R.; de Rafael, E. (Brookhaven National Lab., Upton, N. Y.). Phys. Rev., 162: 1453-62(Oct. 25, 1967). (BNL-11307).

A phenomenological analysis of the $K \rightarrow \pi\pi(I = 2)$ amplitudes, $K^0 \rightarrow \pi\pi(I = 2)$, $\overline{K}^0 \rightarrow \pi\pi(I = 2)$, and $K^\pm \rightarrow \pi^+\pi^0$, in terms of their irreducible isospin amplitudes corresponding to the $\Delta I = \frac{3}{2}$ and $\Delta I = \frac{1}{2}$ transitions, is given with reference to the observed violation of CP invariance. The unitarity condition for the $K^0-\overline{K}^0$ system is also discussed, and an evaluation of the parameters describing the 2π decay modes made. Terms in the unitarity condition referring to the modes $\pi\pi(I = 0)$, $\pi\pi(I = 2)$, 3π, and semileptonic are explicitly taken into account. (auth)

3358 LEPTON POLARIZATION IN PRODUCTION OF N^* BY NEUTRINOS. Song, H. S. (Iowa State Univ., Ames). Phys. Rev., 162: 1604-15(Oct. 25, 1967).

The differential cross sections for the processes $\nu_l + N \rightarrow N^* + l$ and $\overline{\nu}_l + N \rightarrow N^* + \overline{l}$ are considered for a polarized outgoing lepton. The interaction Hamiltonians are expressed in terms of 14 form factors. The differential cross section for a polarized outgoing lepton is put in the form $(d\sigma/dt)_{pol} = \frac{1}{2}(d\sigma/dt)_{unp}\{1 + P\cdot s\}$, where s is the unit vector along the polarization direction so that P is the polarization vector. The polarization vector contains three types of terms in the laboratory system, one parallel to the outgoing lepton momentum l, one perpendicular to l in the production plane, and one perpendicular to the production plane, respectively. The validity of time-reversal invariance and the current-current form for the interaction Hamiltonian with γ_5 symmetry for the lepton current are discussed. The polarization vector can also be obtained experimentally by considering the decay particle of the outgoing lepton. Comparison of the experimental with the theoretical results for the three types of terms in the polarization vector will decide which of the above assumptions for the interaction Hamiltonian is correct. Finally, it is suggested that observation of the polarization of the outgoing N^* resonance or measurement of the cross section with a polarized target might determine which of the several sets of form factors obtained by various authors is the suitable one when the above assumptions for the interaction Hamiltonian are correct. (auth)

3359 RADIATIVE CORRECTIONS TO THE $K_{e3}^\pm$ DALITZ PLOT. Ginsberg, Edward S. (Univ. of Massachusetts, Boston). Phys. Rev., 162: 1570-5(Oct. 25, 1967).

The radiative corrections to the Dalitz plot in $K_{e3}^\pm$ decays are calculated assuming a phenomenological weak K-π vertex and using perturbation theory. The answer depends logarithmically on a cutoff, as is the case for nucleon β decay. An interesting feature of these decays is that they offer a means of measuring the q^2 dependence of the form factors $f_\pm(q^2)$. The radiative corrections contribute an additional energy dependence to the measurements which cannot be separated experimentally. It is found that the radiative corrections are considerable, i.e., greater than 3% in absolute magnitude, over a large portion of the Dalitz plot, and are not particularly sensitive to a reasonable choice of cutoff. (auth)

3360 REMARKS ON THE POLE DOMINANCE VERSION OF THE HYPOTHESIS OF PARTIALLY CONSERVED AXIAL-VECTOR CURRENT. Kim, C. W.; Ram, Michael (Johns Hopkins Univ., Baltimore). Phys. Rev., 162: 1584-8(Oct. 25, 1967).

The dispersion-theory version of the PCAC hypothesis is reviewed and discussed in the case of nucleon leptonic weak decays. The discussion is extended to the case of meson weak decays, and

the feasibility of a direct test of the Goldberger–Treiman relation for the meson case is considered. (auth)

3361 SPIN-3/2 POLARIZATION IN PRODUCTION OF N* BY NEUTRINOS. Song, H. S. (Iowa State Univ., Ames). Contract W-7405-eng-82. Phys. Rev., 162: 1615-18(Oct. 25, 1967). (IS-1535).

The spin-$\frac{3}{2}$ polarization and projection operators are obtained. The polarization of the outgoing N* resonance for the process $\nu_l + N \rightarrow N^* + l$ is treated and the explicit value of the density matrix of the N* resonance is obtained in two special cases, using the explicit values of three form factors obtained by Berman and Veltman and by Albright and Liu. (auth)

3362 SIMPLE SOLUBLE MODEL FOR THE DECAY OF AN UNSTABLE STATE. Pietenpol, J. L. (Brookhaven National Lab., Upton, N. Y.). Phys. Rev., 162: 1301-5(Oct. 25, 1967). (BNL-11323).

A solution is presented for the decay of a discrete state to a continuum via a coupling of Lorentzian form, the continuum extending over all real energy values. Although the model is highly unrealistic, it is of interest because of the unusually simple analytic form of the results. The behavior of the decay solution is examined as a function of the coupling constant, and its relationship to the S matrix is investigated. (auth)

3363 VALIDITY OF SPECIAL RELATIVITY AT SMALL DISTANCES AND THE VELOCITY DEPENDENCE OF THE MUON LIFETIME. Redei, L. B. (Umea Univ., Sweden). Phys. Rev., 162: 1299-1301(Oct. 25, 1967).

The velocity dependence of the lifetime of the muon is investigated under the assumption that the Hamiltonian contains a spatial form factor which in the lab frame (the frame at rest with respect to the neighboring macroscopic bodies) vanishes for distances larger than some length α. In this model there is a violation of the principles of special relativity at small distances. In particular, space-time is anisotropic at distances smaller than α. The lifetime of the muon is calculated to second order in α, and it is shown that there will be about 1% deviation from the usual formula $\tau(v) = (1 - v^2/c^2)^{-\frac{1}{2}}\tau(0)$ (which holds if special relativity is valid at arbitrarily small distances) if, e.g., the muon energy $E_\mu = 10^4$ MeV and $\alpha \sim 7 \times 10^{-18}$ cm. The measurement of the velocity dependence of the muon lifetime at high energies could thus serve as a possible check on the validity of special relativity at small distances. (auth)

3364 MINIMAL INTERACTIONS, CURRENT ALGEBRA, AND APPLICATIONS. Pasupathy, Jagadisan. Rochester, N. Y., Univ. of Rochester, 1967. 107p.

Thesis.

The hypothesis of minimal electromagnetic interaction is extended to the weak interaction and the partially conserved axial vector current equation is modified to $\partial_\mu J_\mu^{\alpha,i} = C\phi^i + \epsilon^{ijk}W_\mu^j J_\mu^{\alpha,k}$(1). Equation (1) is shown to be valid in theories which treat the vector and axial vector currents symmetrically like the quark model and the σ-model but not in unsymmetrical theories like the pseudoscalar or the pseudovector pion nucleon interaction. Equation (1) is sufficient to derive all the low energy applications of current algebra. The relation between the two methods as well as the connection with Nambu's method of chirality conservation is explained. The application to soft-pion production by electron and neutrino is discussed at length. Using projection operators for SU(3) representations the group theoretical equations are solved. Sum rules between threshold amplitudes is obtained. The form factors in the elastic reactions are related to those in the inelastic reactions. They lead to the Adler–Weissberger relation and the conclusion that the axial vector radius is nearly equal to the vector radius. Problems associated with lack of gauge-invariance and nonuniqueness of the choice of the form factors are studied. Following the method of Weinberg the procedure for studying processes with two soft pions is outlined. A parameter-free calculation of the branching ratio of the η-meson for the $2\pi\gamma$ and 2γ modes gives result in excellent agreement with experiment. The vector amplitude in Kl_4 decay is also computed and leads to a prediction of 5 to 10% up-down asymmetry in the distribution of the pions. (Disser. Abstr.)

Strong (General)

Refer also to abstracts 2820, 2822, 2835, 2837, 2851, 2857, and 3423.

3365 (DESY-67/25) UEBER DIE STATISTISCHE BESCHREIBUNG HOCHENERGETISCHER VIELTEILCHENERZEUGUNGSREAKTIONEN. (The Statistical Description of High-Energy Many-Particle Production Reactions). Satz, Helmut (Deutsches Elektronen-Synchrotron, Hamburg (West Germany)). July 1967. 69p. (In German). Dep.

The description of many-particle production processes by means of statistical models is investigated, with particular attention paid to the inclusion of angular momentum conservation in addition to that of energy and momentum. In part I the classical and quantum-mechanical phase space is formulated with full kinematics (all ten additive conservation laws) and its evaluation using the central limit theorem of statistics is discussed. The corresponding extension of the (Fermi) statistical model is carried out in part II; the model thus obtained is then applied to find predictions about integral and differential quantities both for inelastic and for the coupled elastic reactions. Finally the general limits and possibilities of a statistical treatment of production reactions are discussed. (auth)

3366 QUARKS. Zeldovich, Ya. B. (Academy of Sciences, Moscow). At. Energy Rev., 5: No. 2, 3-58(1967).

A general account of the theories in which elementary particles are regarded as systems consisting of simpler sub-elementary units is given. After a historical survey, the quark hypothesis, according to which such sub-elementary units have fractional charges, is expounded. It is shown how this hypothesis, in agreement with experiment, explains the structure of the families of strongly interacting particles known at present, including the family of the baryons, to which the proton and the neutron belong. The electromagnetic properties and the decay and scattering of particles are also shown to be satisfactorily explained. A review of the experimental search for free quarks, with accelerators, in cosmic rays and in ordinary matter is given. It is pointed out that this work has not yet led to any definite conclusions about the existence of quarks. The theory of quark production in the collision of energetic particles and in cosmological conditions is described. (auth)

3367 $SU(6)_W$ AND THE BOOTSTRAP HYPOTHESIS. Capps, Richard H. (Northwestern Univ., Evanston, Ill.). 138-60 of Elementary Particle Physics. Takeda, Gyo; Fujii, Akihiko (eds.). Tokyo, Syokabo Publishing Co. and New York, W. A. Benjamin, Inc., 1967.

A composite model for hadrons is considered within the framework of modern dispersion theory. The question of whether there are forces in certain states that are attractive enough so that composites should exist and be members of lighter hadrons is investigated. The bootstrap hypothesis is assumed in order to treat all particles considered as composites. It is assumed that the mesons M and baryons B in multiplets corresponding to the $\underline{35} \oplus \underline{1}$ and $\underline{56}$ representations in SU(6), respectively, are basic, and that the two-particle states formed from this set dominate the dispersion integrals sufficiently that simple force diagrams involving only this set represent reasonable first approximation to a composite theory of lighter hadrons. Following a discussion of SU(6) and $SU(6)_W$, the problem of bootstrapping the M and B and the properties of the heavier meson and baryon states that are predicted are treated in detail. (L.B.S.)

3368 LIE GROUP OF THE STRONG COUPLING THEORY. Udgaonkar, B. M. (Tata Inst. of Fundamental Research, Bombay). pp 127-35 of Elementary Particle Physics. Takeda, Gyo; Fujii, Akihiko (eds.). Tokyo, Syokabo Publishing Co. and New York, W. A. Benjamin, Inc., 1967.

A brief history is given of the strong coupling theory and the problems and questions that led to a recent revival of interest in the strong coupling series. A review is given of the Cook-Goebel-Sakita (CGS) model, considering, for simplicity, the s-wave scattering of scalar mesons by baryons. The equivalence between the strong coupling condition and static bootstrap condition is then used in order to derive the strong coupling series for nucleon or hyperon isobars, their coupling constants, and their magnetic moments. The possibility of a fine dimensional representations is discussed. (L.B.S.)

3369 MODELS OF HADRONS. Okubo, Susumu (Univ. of Rochester, N. Y.). pp 106-14 of Elementary Particle Physics. Takeda, Gyo; Fujii, Akihiko (eds.). Tokyo, Syokabo Publishing Co. and New York, W. A. Benjamin, Inc., 1967.

Models proposed for hadrons which account for the approximate SU(3) symmetry are investigated using the algebra of currents. The models are grouped into the following categories: (I) fundamental fields are fermions, (a) charges of fundamental fields are fractional, and (b) charges of fundamental fields are integral; and (II) fundamental fields include both fermions and bosons, (a) fundamental fields are unitary triplets, and (b) fundamental fields are unitary nonets. It is concluded that the fractionally charged quark model appears to be the best choice. (L.B.S.)

3370 QUARK SUBSTRUCTURE FOR MESONIC AND BARYONIC STATES. Dalitz, R. H. (Oxford Univ.). pp 55-105 of Elementary Particle Physics. Takeda, Gyo; Fujii,

Akihiko (eds.). Tokyo, Syokabo Publishing Co. and New York, W. A. Benjamin, Inc., 1967.

The quark hypothesis for the triplet sub-units which approximately satisfy SU(6) symmetry in the nonrelativistic limit is reviewed. Accelerator and cosmic ray searches for quarks are also reviewed. The interpretation of the data on mesonic and baryonic states are discussed in detail. In conclusion, a brief summary is given of the elements of success, and the difficulties, of the nonrelativistic quark model for the elementary particle states at the present stage, in its attempt to provide a basis for an understanding of the applicability of SU(6) symmetry to them. (L.B.S.)

3371 HIGH ENERGY STRONG INTERACTIONS OF ELEMENTARY PARTICLES. Bertocchi, L. (CERN, Geneva); Ferrari, E. pp 71-217 of High Energy Physics. Vol. II. Burhop, E. H. S. (ed.). New York and London, Academic Press, 1967.

A review is given of the experimental and theoretical ideas relevant to the dynamical approach to the physics of strong interactions. Only those initial states that are experimentally accessible are considered; i.e., pp, np, $\bar{p}p$, $\pi^{\pm}p$, $K^{\pm}p$, and the reactions initiated by them. Section II gives a review of the experimental situation on elastic scattering, inelastic scattering, charge exchange scattering, quasi-elastic interactions, and inelastic processes with many-particle production. A summary of the general properties of the scattering amplitude follows in Section III. The basic models used for the description of experimental facts on elastic and inelastic interactions are presented in Sections IV and V. Section VI deals specifically with the asymptotic region. (~400 references). (L.B.S.)

3372 PERIPHERAL PROCESSES. Hearn, A. C.; Drell, S. D. (Stanford Univ., Calif.). pp 219-64 of High Energy Physics. Vol. II. Burhop, E. H. S. (ed.). New York and London, Academic Press, 1967.

Early developments of the concept of peripheralism are reviewed. Peripheral models with form factors and with absorption and K-matrix models are discussed. Transition amplitudes for two strongly interacting particles in the initial and final states are investigated, and an analysis is made of the quantitative success and shortcomings of the theoretical analyses in fitting the magnitude of cross sections, their energy and momentum transfer dependence, and the observed decay correlations. The application to photoproduction of secondary beams of strongly interacting particles is considered. (99 references). (L.B.S.)

3373 CURRENT DEFINITION AND MASS RENORMALIZATION IN A MODEL FIELD THEORY. Hagen, C. R. (International Atomic Energy Agency, Trieste, Italy). Nuovo Cim. (10), 51A: 1033-52(Oct. 21, 1967).

It is demonstrated that a field theory of vector mesons interacting with massless fermions in a world of one spatial dimension has an infinite number of solutions in direct analogy to the case of the Thirring model. Each of these solutions corresponds to a different value of a certain parameter ξ which enters into the definition of the current operator of the theory. The physical mass of the vector meson is shown to depend linearly upon this parameter, attaining its bare value μ_0 for the exceptional case in which the pseudovector current is exactly conserved. The limits $\mu_0^2 \to \infty$ and $\mu_0^2 \to 0$ are examined; the former yields results previously obtained for the Thirring model while the latter implies a unique value for ξ and defines the radiation gauge formulation of Schwinger's two-dimensional model of electrodynamics. (auth)

3374 FERMION–ANTIFERMION BETHE–SALPETER EQUATION FOR STRONGLY BOUND SYSTEMS. Ciafaloni, M. (Scuola Normale Superiore, Pisa, Italy. Istituto Nazionale di Fisica Nucleare, Pisa, Italy). Nuovo Cim. (10), 51A: 1090-1106(Oct. 21, 1967).

An analysis is presented of a ladder-type Bethe–Salpeter equation for a strongly bound fermion-antifermion system. The relative-time parity is extended to this case and it is shown that bound-state solutions exist with "wrong" time parity, which are not poles of the S-matrix (on the mass shell). On the basis of the Mandelstam normalization condition these solutions are also shown to have negative norms. As a consequence, it is found that a quark model of this type with scalar interaction probably does not work. Nevertheless, an illustrative calculation of the magnetic moment of the 1^- ground state is performed for scalar interaction. Though this solution is unacceptable, its magnetic moment is of the correct order of magnitude. (auth)

3375 UNIFIED FERMI-YANG AND CHEW-LOW MODELS. Cutkosky, R. E.; Jacobs, M. A. (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev., 162: 1416-25(Oct. 25, 1967).

A unified bootstrap theory is considered which incorporates the features of the Chew–Low and Fermi–Yang models. The baryons are treated as being much heavier than the mesons. In this approximation the self-consistent baryon–meson vertices are shown to incorporate simultaneously the $SU(6)_W$ and $SU(6)_W$ relations. It is pointed out that if the baryons are taken as very heavy, a nearly degenerate sequence of excited rotational states must exist in the crossed channel (baryon–antibaryon); the Chew–Low model is not really self-consistent unless these mesons are all included. The rotational sequence includes exactly the same states as are obtained in the quark model. However, it may be possible to distinguish the two theories through some differences in detail (for example, in the predicted mass splittings). (auth)

3376 PROCEEDINGS OF THE LIPERI SUMMER SCHOOL IN THEORETICAL PHYSICS, AUGUST 1–6, 1966. A. ELEMENTARY PARTICLE PHYSICS. Helsinki, University of Helsinki, 1967. 267p. (CONF-660834-(Pt.A)). DTIE.

Five lectures are included. Separate abstracts are prepared for each lecture. (J.F.P.)

For abstracts of individual papers see: 3395–3397, 3446, and 3520.

Strong (Baryon No. = 0)

Refer also to abstracts 3402, 3456, and 3485.

3377 (CERN-67-23) MESON RESONANCES. Lectures given for the Academic Training Programme, January–February 1967. Montanet, L. (European Organization for Nuclear Research, Geneva (Switzerland)). Sept. 6, 1967. 83p. Dep.

The experimental situation of meson states is reviewed. The basic techniques used in the determination of the properties of the meson states: that is the conservation laws and selection rules, spin–parity analysis, and Dalitz plot are briefly reviewed. Also some of the difficulties often encountered in the analysis of resonances are mentioned: rescattering effects, Peierl's mechanism, interference effects, and Deck mechanism. The phenomenological description of meson states includes the 0^- well-established nonet, the dipion system, the tripion system, the $\bar{K}K$ systems, mesons with strangeness $\neq 0$, the B(1200), the D(1280), and higher-mass resonances. (J.F.P.)

3378 (INP-555/PL/PH, pp 1-15) MULTIPARTICLE ANNIHILATIONS OF ANTIPROTONS IN HYDROGEN. Danysz, J. A. (Institute of Nuclear Research, Krakow (Poland)).

The processes of annihilation of antiprotons, which can be described generally by the formula, $\bar{p} + p \to n_1\pi^+ + n_2\pi^- + n_3\pi^0 + n_4K$, are investigated for the primary antiproton momentum range of 0 to 7 GeV/c. Several examples are shown in which the annihilations with the production of many particles in the final state should be interpreted as the three-particle reactions. Experimental information on cross sections, angular distributions, and angular correlations is summarized, and need for obtaining additional information of resonance production and the relation between various effects and the antiproton momentum is emphasized. A summary is given of various attempts at a theoretical description based on the statistical model of Fermi, the quark model, the model of Koba-Takeda, and the baryon exchange model. (L.B.S.)

3379 (INP-555/PL/PH, pp 17-29) ENERGY DEPENDENCE OF THE EFFECT OF ANGULAR CORRELATIONS IN $\bar{p}p$ ANNIHILATIONS. Czyzewski, Oleg (Institute of Nuclear Research, Krakow (Poland)); Szeptycka, Maria (Warsaw Univ. (Poland). Inst. of Experimental Physics).

A previous study by Goldhaber et al. (Phys. Rev., 120: 300 (1960)) on $\bar{p}p$ annihilations at 1.05 GeV showed a marked difference between the distribution of the opening angle for the pairs of pions of like and unlike charges. A similar effect has been observed for $\bar{p}p$ annihilations at other energies and in π^+p interactions at 5 GeV/c and 8 GeV/c. It is shown that the dependence of the angular correlations on the average pion energy is of the exponential form. (L.B.S.)

3380 (INP-555/PL/PH, pp 31-50) ANGULAR CORRELATION BETWEEN PIONS IN THE ANNIHILATION AT REST $p\bar{p} \to \pi^+\pi^+\pi^-\pi^-$. Zalewski, Kacper (Polish Academy of Sciences, Krakow. Inst. of Physical Chemistry).

The problem of angular correlations between pions in $p\bar{p}$ annihilations is studied according to the symmetrization mechanism of Goldhaber et al. (Phys. Rev. 120: 300 (1960)) and the angular momentum effect used by Cresti et al. (The Sienna International Conf. on Elementary Particles (1963)). The formula for the weight factor is discussed in terms of the uncorrelated jet model. A quantitative discussion is given of the Goldhaber effect in the $p + p \to \pi^+ + \pi^+ + \pi^- + \pi^-$ interaction at rest. (L.B.S.)

3381 BOOTSTRAP OF THE ρ REGGE TRAJECTORY. Gross, David J. (Harvard Univ., Cambridge, Mass.). Phys. Rev. Lett., 19: 1303-5(Nov. 27, 1967).

The amplitude for $\omega + \pi \rightarrow \pi + \pi$ is considered within a dynamical scheme proposed by Mandelstam, based on rising Regge trajectories, the narrow-resonance approximation, and generalized superconvergence relations. The ρ trajectory is shown to qualitatively bootstrap itself. Also, a world consisting only of the particles on a vacuum trajectory is shown to be inconsistent within this approximation. (auth)

3382 SCHWINGER TERMS AND THE JOHNSON–LOW MODEL. Polkinghorne, J. C. (Cambridge Univ., Eng.). Nuovo Cim. (10), 52A: 351-8(Nov. 21, 1967).

A simple discussion of the evaluation of commutators in the Johnson–Low model is given using techniques previously developed for evaluating the asymptotic behavior of Feynman integrals. The canonical terms are obtained and mechanisms for the appearance of Schwinger terms are discussed and some new features exhibited. It is shown that the Schwinger terms depend on detailed dynamical considerations and can be made to vanish by suitably chosen cut-off procedures. (auth)

3383 ALGEBRA OF CURRENT AND $\rho^{\pm} \rightarrow \eta + \pi^{\pm}$ DECAY. Srivastava, Prem P. (International Center for Theoretical Physics, Trieste, Italy). Notas Fis., Cent. Brasil. Pesqui, Fiz., 13: 3-7(1967).

The G-parity violating decay mode $\rho \rightarrow \eta\pi^{\pm}$ is studied using current algebra of scalar densities and is related to the dominant decay mode $\rho \rightarrow 2\pi$ governed by strong interactions. The decay under consideration may provide an independent test of the hypothesis involved in the current algebra approach. (auth)

3384 MULTIPLE POLES AND RESONANCE SPLITTING. Terent'ev, M. V. JETP Lett. (USSR) (Engl. Transl.), 6: 47-9 (July 15, 1967).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu, 6: 521-5(July 15, 1967).

A theoretical analysis of certain singularities that arise when two resonant states (appearing in the same interaction) have nearly equal masses is given. The problem is formulated with the aid of the following example: It is assumed that the mass difference of the mesons (ω) and (ϕ) begins to decrease. The possibility of making the mass difference $m_{\omega} - m_{\phi}$ smaller than the width of each of the resonances is studied. The dependence of the absolute value of the amplitude on the energy at different parameter values is shown. (J.F.P.)

3385 EXPERIMENTAL UPPER LIMIT TO DIFFERENCES BETWEEN THE GRAVITATIONALLY INDUCED ELECTRIC FIELDS NEAR VARIOUS METALS. Witteborn, Fred C.; Pallesen, Michael R. (Stanford Univ., Calif.). Phys. Rev. Lett., 19: 1123-6(Nov. 6, 1967).

Since an understanding of the gravitationally induced electric fields near metals is of importance in evaluating experiments intended to determine the gravitational acceleration of freely falling charged elementary particles, a method for checking these fields near metals by a method independent of those previously used is described. This method is to join two vertically oriented dissimilar metal rods at one end, connect a nanovoltmeter (with extremely high effective impedance) between the rods at the opposite end, and then to invert the rods in the earth's gravitational field, noting any change in voltage. The results for various metals are listed. (J.F.P.)

3386 A BOOTSTRAP CALCULATION ON THE QUARK–ANTIQUARK CHANNEL. Lee, Y. Y.; Chen-Tsai, C. T.; Lee, T. Y. (National Tsing Hua Univ., Hsinchu, Taiwan). Nuovo Cim. (10), 52A: 202-9(Nov. 1, 1967).

A bootstrap program for the quark-antiquark channel is set up to search for meson solutions. It is found that this channel alone is not enough to form the meson 35-plet as bound state. However, the pseudoscalar singlet meson is found to bootstrap itself in this channel. (auth)

3387 A CURRENT ALGEBRA CALCULATION OF THE π-π SCATTERING LENGTHS. Iliopoulos, J. (CERN, Geneva). Nuovo Cim. (10), 52A: 192-201(Nov. 1, 1967).

A new approach is presented for the calculation of the π-π scattering lengths based on current algebra. The parametrization chosen for the amplitude allows for the elastic unitarity cuts. A family of solutions was found which contains Weinberg's results. (auth)

3388 ABSOLUTE UPPER BOUNDS FOR $\pi\pi$ SCATTERING. Lukaszuk, L. (Cambridge Univ., Eng.); Martin, A. Nuovo Cim. (10), 52A: 122-45(Nov. 1, 1967)

Unitarity, crossing and analyticity (in the domain resulting from axiomatic field theory) are combined to derive upper bounds on the pion-pion scattering amplitude inside its analyticity domain and sum rules over the physical pion-pion amplitude, in particular over total cross sections. The bounds are obtained in completely rigorous way and contain no free parameters except the mass of the pion. The assumptions are: the lightest strongly interacting particles are three pseudoscalar particles $\pi^{+}\pi^{-}\pi^{0}$ with equal masses and such that π^{0} is self conjugate, $\pi^{+}\pi^{-}$ are mutual conjugate. It is not necessary to assume that they belong to an isospin triplet. The $\pi\pi$ system has no bound state. The assumption of AFT–with unitarity included–held. (auth)

3389 VECTOR-MESON SUM RULES FROM CURRENT COMMUTATORS. I. Kim, C. W.; Ram, Michael (John Hopkins Univ., Baltimore). Phys. Rev., 162: 1576-84(Oct. 25, 1967).

Vector-meson sum rules are obtained from a charge commutator and from three mixed charge-current commutators using the noncovariant approach. In deriving these results, the most general form is used for the matrix elements of the weak hadron currents and for strong-interaction vertices, consistent with Lorentz covariance. The results are compared with those obtained by dispersion-relation, covariant techniques, and with available experimental data. (auth)

3390 LOW-ENERGY p-WAVE π-π INTERACTION. Olsson, M. G. (Univ. of Wisconsin, Madison). Contract AT-(11-1)-881. Phys. Rev., 162: 1338-42(Oct. 25, 1967).

A sum rule, based on forward dispersion relations, is discussed which makes possible the calculation of the p-wave π-π scattering amplitude near threshold using as input principally the parameters of the ρ-meson resonance. This sum rule contains kinematic factors which suppress both the s-wave amplitude at threshold and the high-energy behavior. The p-wave scattering length is found to be $a_1 = 0.040 \pm 0.005$ (units of m_{π}^{-3}) which is compared with predictions based on partially conserved axial-vector current and with the ρ-meson "tail." (auth)

3391 N/D EFFECTIVE-RANGE THEORY WITH J-INDEPENDENT SHORT-RANGE FORCES. Balazs, Louis A. P. (Univ. of California, Los Angeles). Phys. Rev., 162: 1482-8 (Oct. 25, 1967).

Optical models and Regge-pole theory both suggest that the low partial-wave amplitudes are independent of the angular momentum J at very high energies. This, in turn, implies that short-range forces (faraway cuts) should likewise not depend of J. Therefore an N/D representation is set up in which the distant singularities are approximated in terms of J-independent effective-range parameters. Nearby force singularities are obtained from single-particle-exchange graphs in the usual way. Thus, if the residue and position of a resonance or bound state is known, the effective-range parameters can be adjusted to reproduce it correctly. The N/D formulas then enable the Regge trajectory on which it lies to be calculated. If this is done for the ρ meson, the position of the dip in the πN charge-exchange differential cross section observed near the forward direction at high energies can be computed approximately. (auth)

3392 GOLDBERGER-TREIMAN RELATION FOR A COMPOSITE PION. Atkinson III, Reilly (Tufts Univ., Medford, Mass.). Phys. Rev., 162: 1488-93(Oct. 25, 1967).

The problem of obtaining the Goldberger–Treiman relation for a composite pion is considered. The N/D formalism is used so that the basic assumption is that the pion shows up as a dynamical pole in the pion-channel strong-interaction D matrix. We formally obtain the Goldberger–Treiman relation by examining the residue of the dynamic pion pole in the pion-channel $lv \rightarrow i$ reaction (i lables the ith strong channel). With an approximation suggested by the small mass of the pion, and results of a bootstrap-theory calculation of Dashen and Frautschi, it is suggested that the experimental success of the Goldberger–Treiman relation may be understood in a bootstrap theory. (auth)

3393 UNSUBTRACTED PION-PION DISPERSION RELATION. Franklin, Jerrold (Univ. of California, Livermore). Contract W-7405-eng-48. Phys. Rev., 162: 1526-8(Oct. 25, 1967). (UCRL-70372).

The de Alfaro–Fubini–Furlan–Rossetti assumption on the rapid falloff of amplitudes corresponding to pure I = 2, t-channel exchange is applied to pion-pion forward dispersion relations, and a sum rule is obtained for the pion-pion scattering lengths. The sum rule is fairly well satisfied using the ρ, f, and low-energy s-wave contributions; but the inclusion of the recently discovered g_1 resonance requires the existence of at least one new I = 0 resonance to satisfy the sum rule. (auth)

3394 RELATIVISTIC PARAMETRIZATION OF RESONANCES: THE ρ MESON. Ball, James S.; Parkinson, Michael (Univ. of California, Los Angeles). Phys. Rev., 162: 1509-17(Oct. 25, 1967).

A simple formula is constructed for a resonant scattering amplitude which employs relativistic phase space and possesses

reasonable analytic properties in the total-energy variable. This formula is a direct analog of the nonrelativistic Breit–Wigner formula and contains the same number of parameters. With it, one can immediately calculate electromagnetic form factors and determine the relative contributions of each channel to the formation of the resonance. Application to the ρ meson indicates that the ρ resonance alone is not sufficient to explain the isovector form factor even when many channels are taken into account. It is also noted that the dominant channels for making the ρ are the $N\bar{N}$ and $\pi\omega$, but not the $\pi\pi$. The coupling of the $\pi\omega$ channel to the ρ produces a $\pi\pi \rightarrow \pi\omega$ cross section which has an enhancement near the B-meson mass due solely to the decrease of the ρ pole with increasing energy and the phase space of the $\pi\omega$ channel. The value of the isovector form factor in the timelike region is also calculated. Values for the p-wave $\pi\pi$ phase shift are computed and compared with the nonrelativistic prediction. (auth)

3395 MESON DECAYS. Brown, Laurie M. (Northwestern Univ., Evanston, Ill.). pp 134–69 of Proceedings of the Liperi Summer School in Theoretical Physics, August 1–6, 1966. A. Elementary Particle Physics. Helsinki, University of Helsinki, 1967.

See CONF-660834–(Pt.A).

Some techniques and ideas which are useful in the phenomenological analysis of meson decay are introduced and illustrated using simple examples. Generally the form vectors (or vertex functions) which contain most of the dynamics are little discussed; the emphasis is on kinematical aspects. (auth)

3396 MESON–MESON INTERACTIONS. Singer, Paul (Israel Inst. of Tech., Haifa). pp 61–133 of Proceedings of the Liperi Summer School in Theoretical Physics, August 1–6, 1966. A. Elementary Particle Physics. Helsinki, University of Helsinki, 1967.

See CONF-660834–(Pt.A).

The meson–meson interactions are discussed using a phenomenological approach. The existing interactions are explored and characterized by appropriate coupling constants, or the form of the scattering amplitude is studied without distinguishing between primary or effective meson–meson interactions. Specific interactions considered include $\pi + \pi$, $\pi + K$, and $K^+ \rightarrow \pi^+ + \pi^- + e^+ + \nu$. (J.F.P.)

3397 QUARK SUBSTRUCTURE FOR MESONIC AND BARYONIC STATES. Dalitz, R. H. (Oxford Univ.). pp 170–263 of Proceedings of the Liperi Summer School in Theoretical Physics, August 1–6, 1966. A. Elementary Particle Physics. Helsinki, University of Helsinki, 1967.

See CONF-660834–(Pt.A).

The discussion of quark substructure for mesonic and baryonic states includes the quark hypothesis, the interpretation of the data on mesonic states supposing that these are due to strong binding between quark and antiquark through their mutual potential, and interpretations of data for baryonic states supposing that these are due to the strong coupling of three quarks through the QQ potential. (J.F.P.)

3398 OBSERVABLE EFFECTS OF THE BOX SINGULARITY. Collas, Peter. Los Angeles, Univ. of California, 1966. 101p.

Thesis.

The effect of the leading Landau singularity of the fourth-order single-loop graph in a two-particle → four-particle amplitude is investigated. The amplitude for the graph is evaluated from a dispersion relation in the mass squared of the two particles interacting in the final state, and its behavior is studied using a simple model. The reactions $\bar{p}p \rightarrow \bar{K}K\pi\pi$ and $\bar{p}p \rightarrow \bar{\Lambda}\Lambda\pi^+\pi^-$ are examined in some detail, and peaks are predicted for the amplitude squared in a certain range of the external variables. (Disser. Abstr.)

3399 STUDY OF MULTICHANNEL DYNAMICS IN THE NEW STRIP APPROXIMATION. Chu, Shu-yuan. Berkeley, Calif., Univ. of California, 1966. 55p.

Thesis.

A systematic study of the dynamics of scattering with several coupled two-particle channels is made using the new strip approximation. The existence of a unique solution to the ND^{-1} equations is established from maximal analyticity of the second degree. The method used in an extension of Jones' proof in the single-channel case, making use of an explicit expression for the determinant of D constructed by Gross. The general method is then applied to the particular case of a $\pi\pi$-$K\bar{K}$ two-channel calculation of the ρ-meson, first with fixed-spin particle and then with Reggeized particle exchange as the generalized potential. A detailed discussion of the numerical result is presented with the conclusion that the effect of the inelastic channel ($K\bar{K}$) is not important in the present approximation scheme. (Disser. Abstr.)

3400 GAUGE THEORY OF STRONG INTERACTIONS WITH AN APPLICATION TO THE VECTOR MESON SYSTEM. Brown, David John. Ithaca, N. Y., Cornell Univ., 1966. 74p.

Thesis.

The consequences of requiring a Lagrangian density to be invariant under the transformations of a Lie group with coordinate dependent parameters (Gauge groups) was investigated. The approach of Yang and Mills was followed. Specializing to SU(3) the following results were obtained $g_{BBV}^{(D)} = 0$ and $g_{BBV}^{(F)} = g_{PPV} = g_{VVV}$ which are simply an extension of Sakurai's theory of a universal coupling constant for SU(2) invariant interactions. As a further result it was found that the natural introduction of a quadrilinear term in the vector meson Lagrangian produces an interaction Lagrangian which does not appear to have the form suggested by Sakurai in his conserved vector current theory. A model based on an interaction Lagrangian for the vector mesons that is a consequence of the Gauge theory, namely $L_{INT} = -g\Gamma_{abc}V_a^{\mu}V_b^{\nu}\partial_{\mu}V_{\nu c} - \frac{g^2}{2}(f_{abc}V_b^{\mu}V_c^{\nu})^2$ was investigated. Using this Lagrangian the sign and magnitude of the usual Born exchange terms modified by the point interaction term were calculated. This point interaction was shown to be equivalent to subtractions in the Mandelstam amplitudes. As usual the forces were interpreted as giving rise to sets of particles, in this case nonets with J^P assignments of 0^+, 0^-, 1^- and 2^+. In particular the conclusion was reached that the concept of the vector meson nonet as being formed solely from the pseudoscalar mesons must now be doubted. It seems that the vector mesons must be considered also as bound states of themselves. (Disser. Abstr.)

3401 LOW-ENERGY P-WAVE RESONANCES IN MESON–MESON SCATTERING. Land, David John. Providence, Brown Univ., 1966. 123p.

Thesis.

The bootstrap mechanism, within the S-matrix approach to the strongly-interacting particles, is used in studies of two low-energy p-wave resonances. A self-consistent calculation is performed for the ρ meson in π-π scattering, in which a technique having the feature that it suppresses the high-energy behavior of the scattering amplitude is suggested. The method of calculation is based on a conformal transformation which introduces a new variable, in terms of which an expansion of the scattering amplitude converges throughout the physical region. The coefficients of this expansion are determined from fixed momentum-transfer dispersion relations which give rise to the unitarity and crossed-channel cuts in the partial-wave amplitudes. A self-consistent p-wave resonance is found at 308 MeV. It is concluded that the ρ meson is not capable of producing itself self-consistently and that some other mechanism is responsible for the 750 MeV p-wave resonance observed in the π-π system. In a second calculation, the reciprocal bootstrap idea is applied to the ρ and B mesons in π-ω scattering. The ρ appears as a 1^- bound state in the π-ω system, while arguments favoring a 2^- p-wave B meson are presented. This problem thus represents an alternative approach to the ρ meson as well as an attempt at understanding the B meson as a resonance in the π-ω system. The calculation employs the usual partial-wave dispersion relations in which the driving forces are given by the Born terms for single-particle exchange. Because of the divergence difficulties associated with higher-spin particles and the eventual necessity for an additional parameter in the form of a cutoff it is demanded that only the masses of the ρ and B mesons be self-consistent. Values of the $\pi\rho\omega$ and $\pi B\omega$ coupling constants required to give this self-consistency are compared with the corresponding output parameters characterizing these solutions. The results show that the ρ can be produced self-consistently at its experimental mass, although the B width and $\pi\rho\omega$ coupling constant required to do this are somewhat larger than what experiment indicates. On the other hand, a completely self-consistent B meson can be obtained in reasonable agreement with experiment only if the distant singularities associated with ρ exchange are neglected. Otherwise, ρ exchange is effectively repulsive in the 2^- amplitude, due to the change in sign of the Born term, thus requiring a large B width to produce a resonance at the experimental mass of the B. (Disser. Abstr.)

Strong (Baryon No. = 1)

Refer also to abstracts 3287, 3310, 3397, 3455, and 3485.

3402 (CERN-66-29(Vol.3), pp 93-152) RESONANCES. Miller, Donald H. (California Univ., Berkeley).

The review of baryon and meson resonances is limited to recent advances, with emphasis placed on areas where knowledge is limited and further experimental and theoretical analysis is necessary. (J.F.P.)

3403 (CERN-67-24(Vol.3)) PROCEEDINGS OF THE 1967 CERN SCHOOL OF PHYSICS, RAETTVIK, MAY 21–JUNE 3, 1967. (European Organization for Nuclear Research, Geneva (Switzerland)). Sept. 15, 1967. 156p. Dep.

Two lectures are included, one of which was previously abstracted in NSA. For an abstract of this lecture see abstract number 21: 40207. An abstract was prepared for the remaining lecture. (J.F.P.)

For an abstract of the individual paper see: 3404.

3404 (CERN-67-24(Vol.3), pp 5.1-31) TOPICS IN BARYON RESONANCES. Giacomelli, G. (Istituto Nazionale di Fisica Nucleare, Bologna (Italy)).

Some of the methods used for studying the baryon resonances are discussed placing most of the emphasis on formation-type experiments and, among these, on the results of recent total cross section measurements. The properties of the resonances and some classification schemes are then briefly surveyed. (J.F.P.)

3405 (DESY-67/28) CONDITIONS ON DENSITY MATRIX ELEMENTS AND THEIR APPLICATION IN RESONANCE PRODUCTION. Daboul, Jamil (Deutsches Elektronen-Synchrotron, Hamburg (West Germany)). Aug. 1967. 15p. Dep.

Model-independent upper bounds on the off-diagonal elements of the density matrices are obtained. They follow simply from a geometrical interpretation of these quantities. (auth)

3406 (INP-555/PL/PH, pp 51-63) HEAVY NUCLEON RESONANCES IN HIGH MULTIPLICITY INELASTIC COLLISIONS. Czyzewski, Oleg (Institute of Nuclear Research, Krakow (Poland)).

Evidence for the formation of heavy nucleon isobars in high-energy multiplicity processes is discussed. Experimental information obtained from production experiments is summarized in Chew-Frautschi plots, where nucleon isobars of $^3/_2$ isospin and positive parity and $T = {}^1/_2$ isobars are systematized in terms of Regge recurrences. (L.B.S.)

3407 (INP-555/PL/PH, pp 65-73) A SIMPLE MODEL OF HIGH MULTIPLICITY, HIGH ENERGY INTERACTIONS. Bialkowski, G. (Warsaw Univ. (Poland). Inst. for Theoretical Physics); Sosnowski, R. (Institute of Nuclear Research, Warsaw (Poland)).

Some features of the high energy, high multiplicity interactions are discussed on the basis of experimental data on six-prong π^+p interactions at 8 GeV/c. The proton four-momentum-transfer distribution is first discussed, and a more detailed description is then given of experimental data using a simple model that takes into account the fact (in agreement with experiment) that the distribution of pions in their rest system is statistical. (L.B.S.)

3408 (INP-555/PL/PH, pp 79-99) THE THREE-BODY FINAL STATES IN Kp INTERACTIONS. Eskreys, A. (Institute of Nuclear Research, Krakow (Poland)).

An analysis is made of cross sections and angular and momentum distributions for Kp interactions based on experimental data at 2.0 to 10 GeV. It is concluded that the data indicate an appreciable amount of quasi-three-body and three-body reactions, and their qualitative features support the idea of the double peripheral model. (L.B.S.)

3409 (INP-555/PL/PH, pp 101-12) ORBITAL ANGULAR MOMENTA AT HIGH-ENERGY INTERACTIONS AND THE VAN HOVE OVERLAP FUNCTION. Michejda, L. (Institute of Nuclear Research, Warsaw (Poland)).

An attempt is made to perform a direct determination of the inelastic partial cross sections σ_{in}^{l} from measurements of inelastic final-state contributions, using the π^+p interaction at 8 GeV/c as an example. Overlap functions, which determine the contributing partial waves, are computed for various inelastic final states. A comparison of the computed σ_{in}^{l} with those expected from the elastic scattering shows that the assumptions used for the many-body wave functions were incorrect. This is also shown from comparison of the overall overlap function with the differential elastic cross section. It is concluded that a direct phase measurement is impossible, and thus one is left with the possibility of trying various models which would yield a plausible phase dependence. (L.B.S.)

3410 (INR-833/VI) FOUR: MOMENTUM TRANSFER DISTRIBUTION IN HIGH ENERGY, HIGH MULTIPLICITY REACTIONS. Bialkowski, G.; Sosnowski, R. (Institute of Nuclear Research, Warsaw (Poland)). 1967. 10p. Dep.

The four momentum transfer distribution to the secondary nucleon in high energy, high multiplicity pion-proton interactions is discussed. It is shown that introducing corrections for the available phase space distributions of the four momentum transfer t in many body reactions are obtained similar to those for two body processes. It is demonstrated that the most characteristic features of high multiplicity $\pi^+ - p$ interactions at 8 GeV/c can be reproduced assuming that the transition matrix element for these interactions depends only on t. (auth)

3411 (JINR-E2-3559) MESON FORM-FACTORS. Micu, M. (Joint Inst. for Nuclear Research, Dubna (USSR)). Lab. of Theoretical Physics). 1967. 5p. Dep.

Some commutation relations obtained from current algebra are considered. They give nontrivial solutions for pseudoscalar meson form factors in the approximation of single particle intermediate state. (auth)

3412 (TH-216) IS SATURATION A GOOD APPROXIMATION TO SUM RULES? Diu, B. (Paris Univ., Orsay (France). Laboratoire de Physique Theorique et Hautes Energies). Sept. 1967. 9p. Dep.

The application of superconvergence considerations to static models especially the πN one is discussed. It is shown that bootstrap amplitudes are not automatically superconvergent, and that saturation of the sum rule is not a test of superconvergence. (J.F.P.)

3413 (UCRL-17873) EVALUATION AND FUTURE OF THE REGGE POLE MODEL FOR πN SCATTERING AT HIGH ENERGIES. Rarita, William (California Univ., Berkeley. Lawrence Radiation Lab.). Oct. 6, 1967. Contract W-7405-eng-48. 7p. (CONF-671203-1). Dep. CFSTI.

From Conference on πN Scattering, Irvine, Calif.

A fairly complete analysis was previously made of $\pi + N$ scattering at small momentum transfers and high energies according to the Regge pole model in which the dominant poles in the crossed channel are P, P', and ρ (Rarita, Riddell, Chiu, and Phillips, Lawrence Radiation Laboratory report UCRL-17523, (April 1967)). New data are given on the phase of the forward scattering amplitudes for $\pi^+ + p$ and $\pi^- + p$ interactions after the completion of the analysis in the reference cited. These data are shown together with the calculated values obtained from solution (3) of the cited reference. (J.F.P.)

3414 π^-–p CHARGE-EXCHANGE SCATTERING NEAR 2 GeV/c. Minami, S. (Osaka City Univ.). Nuovo Cim. (10), 52A: 577-87(Nov. 21, 1967).

π^--p charge exchange scattering near 2 GeV/c is described in terms of the amplitudes due to ρ-exchange and one-nucleon-exchange in addition to the resonant amplitude. It is shown that the experimental results can be explained fairly well by such an approach. Since the resonant amplitude has a large effect on the behavior of $d\sigma/d\Omega$ in the backward direction, measurements of backward scattering near 2 GeV/c give important information concerning the existence of a new resonant state whose mass is nearly equal to 2200 MeV. The polarization of recoil nucleons is predicted with the same model. Moreover the interference between the one-meson-exchange amplitude and the one-nucleon-exchange amplitude is discussed by paying attention to its effect on the behavior of $d\sigma/d\Omega$ at high energy. (auth)

3415 EXTENSION OF THE AXIOMATIC ANALYTICITY DOMAIN: PION–NUCLEON SCATTERING. Sommer, G. (CERN, Geneva). Nuovo Cim. (10), 52A: 373-88(Nov. 21, 1967).

Starting from analyticity in the topological product of the cut s-plane and the circle $|t| < 1.83\mu^2$ and using unitarity several times, the domain of validity of fixed-t dispersion relations for elastic πN scattering is extended to a larger domain $D^{\pi N}$ which is shown to contain the negative real axis from $t = 0$ to the "inelastic point" $t = -18.0\mu^2$. Thus, as in meson-meson scattering, the only reason which prevents one from continuing further to the left, is lack of knowledge about possibly occurring singularities above inelastic threshold. Using also a recent result of Bessis and Glaser, the best domain is found to be the intersection of the large Lehmann ellipse for $s = (M + 2\mu)^2$ with the large Lehmann ellipse for $s = (M + 2\mu)^2 + 8\mu(M + \mu)$. In the elastic region the analyticity domain of the absorptive part extends to the border of the Mandelstam support. Partial-wave amplitudes are found to be analytic in two disconnected regions which touch the circle $|s| = M^2 - \mu^2$ from inside and outside in $s = M^2 - \mu^2$. (auth)

3416 CAUSALITY AND ANALYTICITY IN πN RESONANT WAVES. Ranada, A. F. (Junta de Energia Nuclear, Madrid). Nuovo Cim. (10), 52A: 486-505(Nov. 21, 1967).

The requirements of causality and finite range lead to analytic expressions for the S-matrix in πN resonant waves. The singularities in the complex energy plane are obtained. From them it is easy to calculate the mass and width of the resonances. It is shown that a resonance is a rather complex phenomenon characterized by several mass values which can be very different. For

instance, the strange behavior of the P_{11} resonant state is due to this fact. (auth)

3417 REGGE POLE PHENOMENOLOGY AT HIGH ENERGIES. Udgaonkar, B. M. (Tata Inst. of Fundamental Research, Bombay). pp 22-36 of Elementary Particle Physics. Takeda, Gyo; Fujii, Akihiko (eds.). Tokyo, Syokabo Publishing Co. and New York, W. A. Benjamin, Inc., 1967.

The results of applications of the Regge pole model to the analysis of total cross sections, real parts of forward elastic scattering amplitude, and the amplitude for the charge exchange process $\pi^-p \to \pi^0n$ are summarized. Other applications are briefly discussed, which include backward elastic scattering cross sections; differential cross sections for other charge exchange and inelastic two-body or quasi-two-body processes; elastic differential cross sections; and polarization parameters in processes such as $\pi^\pm p$ elastic scattering and $\pi^+p \to K^+\Sigma^+$. (L.B.S.)

3418 NEW EXPERIMENTAL EVIDENCE ON REGGE POLES IN HIGH ENERGY SCATTERING. Frautschi, Steven C. (California Inst. of Tech., Pasadena). Contract AT(11-1)-68, pp 37-48 of Elementary Particle Physics. Takeda, Gyo; Fujii, Akihiko (eds.). Tokyo, Syokabo Publishing Co. and New York, W. A. Benjamin, Inc., 1967.

New evidence on Regge poles in high energy scattering is described, namely, that Regge couplings sometimes have predictable zeros when α passes through integers or half integers. If, in addition, one trajectory dominates, the cross section has a highly visible dip when its coupling vanishes. The coupling zeroes responsible for the dips are classified into two types: signature zeroes and nonsense zeroes. The signature zeroes are discussed, and the ideas are then applied to backward $\pi^-p \to \pi^-p$ and $\pi^+p \to \pi^+p$ scattering. Nonsense zeroes are considered using the example $\pi^-p \to \pi^0n$ at small t, analyzed in terms of pure ρ-trajectory exchange. Reactions where several trajectories are exchanged are briefly discussed. (L.B.S.)

3419 ELASTIC AND INELASTIC CHARGE EXCHANGE PROCESSES IN THE QUARK MODEL. Bialas, A. (Univ., Krakow. Inst. of Nuclear Physics, Krakow); Gula, A.; Muryn, B. Acta Phys. Pol., 32: 443-59(1967).

Two-body charge-exchange processes, with or without resonance production are discussed in the framework of the generalized quark model. Relations between the cross sections and spin density elements are derived and compared with the experimental data. The comparison shows a rather good agreement for the density matrix elements. On the other hand, relations between the cross sections predicted by the model seem to disagree, in general, with the data. (auth)

3420 STUDY OF ANGULAR CORRELATIONS IN 3-BODY FINAL STATES. Allison, W. W. M.; Lyons, L. (Oxford Univ.). Nuovo Cim. (10), 51B: 404-18(Oct. 11, 1967).

Some features of the single-particle exchange model are extended to describe the double peripheral production of three-body final states. A series of angular distributions is investigated for the processes $K^-p \to \Sigma^0\pi^+\pi^-$ and $K^-p \to K^{*-}\pi^+n$ at 6 GeV/c and their features are related to the spin parity properties of the exchanged particles. It is shown that the matrix elements for these processes can be related by crossing symmetry to familiar matrix elements for two-body production. An azimuthal angle φ is defined which is the analytic continuation of the azimuthal decay angle of a resonance in the two-body physical region. (auth)

3421 CONSPIRING REGGE TRAJECTORIES AND THE POLARIZATION IN HIGH-ENERGY, CHARGE-EXCHANGE, PION–NUCLEON SCATTERING. Sertorio, L. (Iowa State Univ., Ames); Toller, M. Phys. Rev. Lett., 19: 1146-8(Nov. 6, 1967). (IS–1671).

It was previously suggested that the polarization observed in high-energy, charge-exchange, pion-nucleon scattering is due to the interference between the contribution of the ρ trajectory and the contribution of another new trajectory ρ' with the same quantum number. It is shown that the contradiction between the sum rule and the available polarization measurements can be avoided by assuming that the spin-nonflip residue of the ρ' pole has a zero for t = 0. The analysis is carried out assuming that the ρ' trajectory is of the type β according to the classification given by Gribov and Volkov. (L.B.S.)

3422 STUDY OF THE REACTIONS $K^+p \to K\pi N$ AT 735 AND 785 MeV/c. Filippas, T. A. (CERN, Geneva); Henri, V. P.; Jongejans, B.; (and others). Nuovo Cim. (10), 51A: 1053-73 (Oct. 21, 1967).

Incoming K^+ momenta of 735 and 785 MeV/c were chosen to study the reactions $K^+p \to K\pi N$ below the $K^*(890)$ and $N^*(1236)$ production thresholds in the hope of observing the production of the $\varkappa$-meson if it exists. A broad enhancement is observed in the $(K\pi)^+$ mass spectrum, which could be attributed to the production of a $\varkappa$-meson of mass ~725 MeV, width ~50 MeV and cross section <200 μb at 785 MeV/c. A more likely explanation is offered by assuming an interference between the low-energy tail of the $N^*(1236)$ and an S-wave $p\pi^+$ background without invoking the production of $\varkappa$-mesons. Simple assumptions concerning the amplitudes of the N^* tail and of the $p\pi^+$ background lead to production and decay distributions in good agreement with the experimental spectra. (auth)

3423 USE OF HELICITY AMPLITUDES IN SUPERCONVERGENT SUM RULES. Odorico, R. (Univ., Trieste, Italy). Nuovo Cim. (10), 51A: 1021-32(Oct. 21, 1967).

Superconvergent sum rules are treated using the t-channel c.m.s. helicity amplitudes of Jacob and Wick. The behavior under crossing $s \rightleftharpoons u$ of the superconvergent amplitudes is found to take quite generally a very simple form. Regge-pole contributions to the sum rules are considered: it is shown that there are cancellations between the contributions to the right- and left-hand cuts, in such a way to allow the existence of more sum rules. Contributions of s-channel singularities to the superconvergent sum rules which arise in such a framework may be evaluated directly as is shown in a particular example: the $\omega - N$ scattering. As a whole a rather simple and systematic technique to treat superconvergent sum rules is obtained which is relatively manageable also when high spins are involved. (auth)

3424 STUDY OF TWO-PION EXCHANGE CONTRIBUTIONS TO QUASI-ELASTIC SCATTERING AT HIGH ENERGIES. Smrz, P.; von Baeyer, H. C. (McGill Univ., Montreal). Nuovo Cim. (10), 51A: 879-98(Oct. 21, 1967).

The two-pion exchange contributions to the absorptive amplitude are estimated for the processes $\gamma p \to \rho p$, $\pi p \to A_1 p$, $\pi p \to A_3 p$, $pp \to N^*p$ for $N^*(1400)$ and $N^*(1520)$ and $\pi p \to \omega N^*(1238)$. The off-shell πN scattering amplitude in the Feynman diagram is replaced by its experimental on-shell value. It is found that, with appropriate form factors, it is possible to fit the shape of the differential cross section in all cases, but the absolute magnitude predicted by the model is too small for the processes $\gamma p \to \rho p$, $\pi p \to A_3 p$ and $\pi p \to N^*_{33}\omega$. Possible reasons for this failure are discussed and the model is compared to similar ones suggested by other authors. (auth)

3425 KN SUPERCONVERGENCE SUM RULES AND REGGE-POLE PARAMETERS. Lusignoli, M. (Univ., Rome); Restignoli, M.; Violini, G.; Borgese, A.; Colocci, M. Nuovo Cim. (10), 51A: 1136-40(Oct. 21, 1967).

Four nontrivial superconvergence relations for forward KN are derived, which are found to be consistent with the usual determinations of the leading Regge-pole parameters. (L.B.S.)

3426 REGGE CUT IN $\pi^-p \to K^+\Sigma^-$. Mickens, R. E. (Brandeis Univ., Waltham, Mass.). Nuovo Cim.(10), 51A: 1122-23 (Oct. 21, 1967).

The existence of Regge cuts in the $\pi^- + p \to K^+ + \Sigma^-$ interaction is investigated, assuming that the double charge exchange in the t-channel is due to the exchange of a ρ and a K^*. Relations are obtained for the position of the branch point, the cross section at high energy, and the polarization. (L.B.S.)

3427 PION–NUCLEON INTERACTIONS. Hamilton, J. (NORDITA, Copenhagen). pp 193-339 of High Energy Physics. Vol. I. Burhop, E. H. S. (ed.). New York and London, Academic Press, 1967.

In section I an account is given of the basic properties of the pion: spin, parity, isospin, etc. This is presented in the form of a historical account of the basic experiments which determine these properties. The analyses of P-wave and S-wave pion-nucleon scattering are treated in sections II and III, respectively. The necessary dispersion theory ideas and techniques are developed throughout. Finally, in section IV, the theory is applied to make predictions for higher energies and higher angular momenta, and the predictions are compared with the experimental data. (106 references and bibliography). (L.B.S.)

3428 REGGE-POLE FIT OF THE REACTION $K^+ + p \to K^0 + \Delta^{++}(1238)$. Krammer, M.; Maor, U. (CERN, Geneva). Nuovo Cim. (10), 52A: 308-13(Nov. 1, 1967).

It was shown that a Reggeized $\rho + A_2$ exchange model fits the reaction $K^+ + p \to K^0 + \Delta^{++}$ in the few GeV region, if the A_2 trajectory goes through zero around $t = -0.5$ $(GeV/c)^2$ and if it couples to "nonsense" channels. (auth)

3429 STABILITY OF CURRENT ALGEBRA PREDICTION FOR THE RENORMALIZED AXIAL COUPLING CONSTANT. Williams, R. M. (Imperial Coll. of Science and Tech., London) Nuovo Cim. (10), 52A: 107-15(Nov. 1, 1967).

One-particle approximations to the completeness relation are

compared with the Adler–Weisberger summation. Predictions for the renormalized axial-vector coupling constant, obtained by saturation of axial charge commutators with the nucleon and isospin-$\frac{3}{2}$ resonances in the infinite-momentum representation, imply the need to include more states with isospin $\frac{1}{2}$, if degenerate masses are assumed. (auth)

3430 $U_{6,6}$ AND SUPERCONVERGENT SUM RULES FOR MESON–BARYON SCATTERING. Jones, H. F.; Scadron, M. D. (Imperial Coll. of Science and Tech., London). Nuovo Cim. (10), 52A: 62-72(Nov. 1, 1967).

Superconvergent sum rules are derived for $\pi N^* \rightarrow \pi N^*$, two of which agree with $U_{6,6}$ when saturated by N and N^* poles in the equal-mass limit. Saturation for physical masses gives $\Gamma_{N^*} =$ 84 MeV. It is pointed out that those sum rules which agree with $U_{6,6}$ for $\pi N \rightarrow \pi N^*$ and $\pi N^* \rightarrow \pi N^*$ do so also for all analogous strange-particle reactions. The special status of these sum rules is discussed. (auth)

3431 SUPERCONVERGENCE RELATIONS FOR PION-BARYON SCATTERING. Dass, Guru Vachan (Atomic Energy Research Establishment, Harwell, Eng.); Michael, C. Phys. Rev., 162: 1403-9(Oct. 25, 1967).

Superconvergence relations are discussed for the spin-flip amplitudes in pion-baryon scattering at t = 0 and at u = 0. These sum rules are evaluated in the resonance saturation approximation and in this case an extension of the derivation is given. This allows the sum rules to be discussed even if the relevant leading Regge trajectory lies above zero at t = 0 for mesons or above $-\frac{1}{2}$ at u = 0 for baryons. All 14 possible sum rules are considered, as well as the moment sum rules, which require stronger assumptions. The spin-flip sum rules are well satisfied for $\pi N \rightarrow \pi N$, and in the other cases the ρ and pion couplings to Σ, Λ, and Ξ required to satisfy the relations are in agreement with other models. The moment sum rules are less convergent and so more difficult to test, but for πN the moment sum rule for $B^{(-)}$ at t = 0 is not satisfied with resonance saturation, and this fact can be understood. (auth)

3432 SEMIPHENOMENOLOGICAL CALCULATION OF LOW-ENERGY s-WAVE π-N SCATTERING. Martin, B. R. (Brookhaven National Lab., Upton, N. Y.). Contract AT(30-2)-Gen-16. Phys. Rev., 162: 1448-53(Oct. 25, 1967). (BNL-11427).

A semiphenomenological calculation of s-wave π-N scattering is presented, based on a method of approximately solving coupled, twice-subtracted, s-wave π-N partial-wave dispersion relations. Unitary trial functions are used to represent the low-energy physical region and to calculate contributions to s-wave π-N scattering due to the nearby singularities produced by the same processes in the crossed u channel. Contributions due to other nearby singularities are calculated using experimental data. Short-range forces are incorporated by imposing a unitary sum rule on the solutions. Unitarity and crossing symmetry are approximately imposed by varying the parameters of the trial functions until the real parts of the amplitudes, as calculated from the dispersion relations, are consistent with those given by the trial functions in both the low-energy s-channel physical region and part of the nearby crossed u-channel physical region. Self-consistent solutions are found which are compatible with experiment. (auth)

3433 MODIFIED REGGE REPRESENTATION FOR BACKWARD π^-p ELASTIC SCATTERING. Carnahan, W. H. (Western Reserve Univ., Cleveland). Phys. Rev., 162: 1479-81(Oct. 25, 1967).

The modified representation proposed by Freedman and Wang is applied to the π^-p backward elastic scattering. The "full" contribution is utilized and the angular distributions are fitted by a linear energy dependence of the residue. (auth)

3434 LOW-ENERGY CONSTRAINTS ON PION PRODUCTION AMPLITUDES IN π N SCATTERING. Chang, Lay-Nam (Univ. of California, Berkeley). Phys. Rev., 162: 1497-1508(Oct. 25, 1967).

Using the hypothesis of the partially conserved axial-vector currents, and specific assumptions on the equal-time commutators of these currents, a calculation of the pion production amplitude near threshold of the πN system has been attempted. The resulting matrix elements are contrasted with those obtained previously by other means, and a comparison with existing data on the total reaction cross section is made. Agreement is favorable for the energy range considered. Unlike previous studies of the production amplitudes where direct π-π interactions are thought to play a substantial role, the present calculation ignores all possibilities of strong π-π effects, and incorporates only those π-π scattering effects required by the consistency of the current-algebra approach. The evaluation of these contributions requires some assumptions on the equal-time commutators of pseudoscalar and scalar densities. Finally, suggestions are made on extensions of the present approach based on resonance models. (auth)

3435 SPIN-PARITY-3/2$^-$ BARYONS AND SINGLET-OCTET MIXING. Masuda, N.; Mikamo, S. (Univ. of Wisconsin, Madison). Contract AT(11-1)-881. Phys. Rev., 162: 1517-20(Oct. 25, 1967). (COO-881-108).

Recent experimental data are used to examine the effects of possible SU(3) mixing among the spin-parity-$\frac{3}{2}^-$ baryons. It is found that the mixing model is a quite reasonable one to account for the various decay widths of the members. With a mixing angle $\theta = 22.5°$, the following optimum values of the parameters are obtained: F/D ≈ 1.1, the ratio of the coupling of $\{8\}\otimes\{8\}$ to $\{1\}$ and $\{8\}\otimes\{8\}$ to $\{8\}$ ≈ 2.5, and inverse interaction radius X ≈ 1000 MeV. Predicted decay widths of the members are also presented. (auth)

3436 APPLICATION OF $SU(6)_W$ IN A MODEL FOR VECTOR-MESON PRODUCTION AT HIGH ENERGIES. Arnold, Richard C. (Argonne National Lab., Ill.). Phys. Rev., 162: 1334-7(Oct. 25, 1967).

A double-Regge-pole model incorporating SU(3) symmetry, previously applied to pseudoscalar meson-baryon exchange reactions, is extended to include certain vector-meson production reactions with $SU(6)_W$ symmetry imposed at the forward direction. A large number of predictions for forward vector-meson production cross sections are obtained in terms of pseudoscalar-meson cross sections. These are compared where possible with the meager data available above 3 BeV/c, with generally favorable results. (auth)

3437 STUDY OF THE ρ^0 MESON FORMED IN $\pi^- + p \rightarrow \pi^- + \pi^+ + n$ BETWEEN 1.38 AND 3.00 GeV/c. Howard, C. G.; Vittitoe, C. N. (Ohio Univ., Athens). Phys. Rev., 162: 1323-7 (Oct. 25, 1967).

The final state of $\pi^- + p \rightarrow \pi^- + \pi^+ + n$ has been studied from data at laboratory pion momenta of 1.38, 1.71, 2.75, and 3.00 GeV/c. The ρ^0 resonance dominates the final state throughout the region. The ρ^0 production and decay angular distributions are compared with Gottfried and Jackson's one-pion-exchange model including absorption effects. The data are in better agreement with the model at the higher momenta, as expected. The $\pi\pi$ effective-mass distribution with $\Delta^2 \leq 4\mu^2$ and $|\cos\theta_{GJ}| < 0.3$ for the combined data peaks near 730 MeV with 255 events in the plot. The effective-mass distribution without kinematic restrictions gives a ρ^0 peak at 765 MeV with 6744 events. (auth)

3438 MULTIPLE π^0 PRODUCTION. Perrin, Robert (Harvard Univ., Cambridge, Mass.). Phys. Rev., 162: 1343-50 (Oct. 25, 1967).

Using a gradient-coupling model as an effective Lagrangian, the cross section for the emission of arbitrary numbers of soft neutral pions in high-energy scattering processes is obtained in the region s, $-$t, $-$u $\gg M^2$ as an infrared factor times the corresponding elastic cross section. A formula relating the average number of soft π^0's to their average total energy is derived, and the possibility is discussed of interpreting large-angle elastic scattering as the shadow of soft-pion emission. (auth)

3439 CONSTRAINT ON THE DOUBLE-PION-PRODUCTION AMPLITUDE IN PION–NUCLEON COLLISIONS IMPLIED BY A PARTIALLY CONSERVED AXIAL-VECTOR CURRENT. Kamal, A. N.; Levers, R. G. (Univ. of Alberta, Edmonton, Can.). Phys. Rev., 162: 1543-50(Oct. 25, 1967).

A constraint between the "nonpole" part of the pion-production amplitude and the pion-nucleon elastic scattering amplitude was derived using the hypothesis of partially conserved axial-vector current (PCAC). An attempt was made to evaluate this nonpole part of the pion-production amplitude, at the unphysical values of the invariants, under the assumption that the important processes are the one-pion-exchange process and the processes involving at least one nucleon pole. This allows the off-mass-shell pion-pion amplitude to be evaluated. It is shown that in the isobaric-spin-1 and -2 states the evaluated off-shell pion-pion amplitudes are not inconsistent with those evaluated on the basis of the algebra of currents and PCAC. In the isobaric-spin-0 state our results, with our approximations, are at variance with those of the algebra of currents and PCAC. It is shown that if the nonpole pion-production amplitude were assumed to be dominated by the one-pion-exchange process alone the results would agree remarkably well with those obtained using algebra of currents and PCAC. (auth)

3440 MODEL CALCULATIONS AND THE EQUAL MASS SPACING OF THE DECUPLET. Slansky, Richard C. (Univ. of Calif., Berkeley). Contract W-7405-eng-48. Phys. Rev., 162: 1627-39(Oct. 25, 1967). (UCRL-17535).

The response of the decuplet masses to octet perturbations of the meson and baryon masses and couplings is studied in an N/D model of baryon-meson scattering. It is found that the equal mass spacing of the decuplet is satisfied in the model, even for large values of the symmetry breaking. The numerical inaccuracy of several forms of perturbation theory indicates that the physical baryon masses represent a large symmetry breaking in the calculation of the decuplet; for physical baryon and meson masses and SU(3)-symmetric couplings, the first-order mass shift is about one-half the value given by the exact solution of the model. This suggests that the octet output of the masses is specially enhanced in the exact solution of the model, just as in the first-order Dashen–Frautschi theory. The rate at which the first-order formulas become accurate as the degenerate mass of the external particles is increased is examined. The octet sum rules of S-matrix elements break down quickly as the octet perturbations are increased. (auth)

3441 GENERALIZED POLE-DOMINANCE HYPOTHESIS, CURRENT ALGEBRA, AND S-WAVE K^+p SCATTERING. Roy, Probir (Stanford Univ., Calif.). Contract AT(04-3)-515. Phys. Rev., 162: 1644-9(Oct. 25, 1967). (SLAC-PUB-317).

A test of generalized PDDAC (pole dominance of the divergence of the axial current) for $A_\mu^{K^\pm}$ is made by calculating the S-wave scattering length and effective range for K^+p scattering using current-algebra techniques. First-order corrections in the kaon four-momentum are shown to be zero for the scattering length and small for the effective range. From a comparison with experiment, PDDAC for the K meson seems to be good within 30%. (auth)

3442 MASS DIFFERENCES, SU(3), AND MESON-BARYON SCATTERING. Chu, Robert Y. L. (Tufts Univ., Medford, Mass.); Everett, Allen E. Phys. Rev., 162: 1710-16(Oct. 25, 1967).

A study is made of the effect of mass differences within multiplets on relations between scattering amplitudes predicted by SU(3) in a model in which the matrix ND^{-1} method and determinantal approximation are used to calculate the one-baryon exchange contribution to the P_8 partial wave in octet-octet meson-baryon scattering; the model is the same as that used by Wali and Warnock to calculate decuplet mass splittings. The unphysical cut is taken to be completely SU(3) symmetric, so that the only symmetry breaking arises from the mass differences in the scattering particles. The predicted relation among the amplitudes for the reactions $\pi^+p \to \pi^+p$, $\pi^+p \to K^+\Sigma^+$, and $K^+p \to K^+p$, and the predicted equality of the amplitudes for $K^-p \to K^0\Xi^0$ and $K^-p \to \Sigma^-\pi^+$ are examined. The results confirm an earlier calculation based on a simple potential model, in that one finds that the mass splittings may produce very large violations (as much as a factor of 10 in the amplitudes in one case) of the predicted SU(3) relations at low energies; one cannot be sure of the precise validity of these relations until the center-of-mass energy becomes greater than the masses. Thus, even the large discrepancy between the Ξ^0K^0 and $\Sigma^-\pi^+$ production cross sections near threshold, as well as the perhaps 20% disagreement in these cross sections reported at higher energy, could be due to mass differences alone; similar conclusions hold for all other apparent violations of SU(3) in scattering processes so far reported. It seems to make little difference whether one compares different reactions at, e.g., the same final or same initial Q values. It is noted that the production cross sections near threshold for $K^+\Sigma^+$ and $K^0\Xi^0$, as predicted by this rather crude dynamical model, are much too large when SU(3) and the usual value of the D-F mixing parameter, $f = 0.35$, are used; the P_8 contribution to the former, alone, is about 10 times the experimental value. Qualitative agreement can be obtained with these small production cross sections in the context of the model by taking f to be about 0.7; this, however, results in a value of the NAK coupling constant which may be unacceptably large. (auth)

3443 FORM FACTORS AND ANTISYMMETRIC NUCLEON WAVE FUNCTIONS IN THE QUARK MODEL. Kreps, R. E.; de Swart, J. J. (Univ. of Pittsburgh). Contract AT(30-1)-3829. Phys. Rev., 162: 1729-33(Oct. 25, 1967). (NYO-3829-4).

An explicit antisymmetric spatial wave function for the nucleons in the quark model is constructed which yields a form factor in reasonable agreement with the experimental data. One consequence is that it is not necessary on the basis of the present data to discard Fermi statistics for the quarks in a single triplet model. (auth)

3444 HIGH-ENERGY SUM RULE FOR Kp SCATTERING. Razmi, M. S. K.; Ueda, Y. (Univ. of Toronto). Phys. Rev., 162: 1738-40(Oct. 25, 1967).

A sum rule of the superconvergent type is obtained for forward, elastic Kp scattering. It connects Regge parameters with an integral over total cross sections. A numerical evaluation is carried out and the Regge parameters thus determined are compared to those obtained from a fit to the high-energy data. Impressive agreement is found. (auth)

3445 K^+n CHARGE EXCHANGE AND THE ρ' REGGE TRAJECTORY. Rarita, William; Schwarzschild, Bertram M. (Univ. of California, Berkeley). Contract W-7405-eng-48. Phys. Rev., 162: 1378-85(Oct. 25, 1967). (UCRL-17572(Rev.)).

Finding that the Regge exchange of ρ and A_2 fails to describe the K^+n charge-exchange data at 2.3 GeV/c (the highest energy available to date) when a simultaneous fit is attempted with higher-energy data on K^-p and π^-p charge exchange and $\pi^-p \to \eta^0n$, a second, lower-lying ρ-type trajectory (ρ') is introduced. This also provides a possible mechanism for the puzzling π^-p charge-exchange polarization. It is found that all these data, (including the polarization), can be fitted simultaneously together with related total cross-section differences up to 20 GeV/c, with a ρ' whose spin-1 mass is 1.0 GeV [perhaps the $\delta(965)$?] and whose $t = 0$ intercept, 1.1 units of angular momentum below the ρ, agrees roughly with the ρ' proposed by Högaasen and Fischer to describe forward $\bar{p}p$ and np charge exchange, where the (ρ,A_2) model also fails. The ρ and A_2 trajectories turn out essentially traditional. In the fit, only small SU_3 breaking is allowed between the $K\bar{K}$ and $\pi\pi$ (or $\eta^0\pi$) couplings to the trajectories. The fit is further constrained to obey the sum rule of Igi and Matsuda. In fitting the K^+ data at 2.3 GeV/c, a deuteron correction is included, and exact Legendre functions rather than the high-energy asymptotic Regge forms are employed. Predictions are made for higher-energy K^+ charge exchange. (auth)

3446 PION–NUCLEON INTERACTIONS. Hamilton, J. (Nordita, Copenhagen). pp 22-60 of Proceedings of the Liperi Summer School in Theoretical Physics, August 1–6, 1966. A, Elementary Particle Physics. Helsinki, University of Helsinki, 1967.

See CONF-660834-(Pt.A).

The basic assumptions of dispersion theory, analyticity, crossing symmetry, and unitarity are considered for $\pi + N$ interactions. (J.F.P.)

3447 LOW ENERGY INTERACTIONS IN THE KAON–NUCLEON SYSTEM. Weil, Chanoch. Minneapolis, Univ. of Minnesota, 1966. 78p.

Thesis.

An attempt at comparing experimental kaon nucleon scattering data with predictions of a forward scattering dispersion relation is made. Such an attempt was previously successful in the determination of the pion nucleon scattering parameters. The difficulty in an application to the KN system is that the absorptive part of the scattering amplitude is nonvanishing in regions other than those in which the optical theorem holds. These include, in addition to poles for Λ and for Σ, a continuum of unphysical scattering states from the $\pi\Lambda$ to the $\bar{K}N$ threshold. Such a continuum is absent in the πN system. Both K^-p and K^+p total cross section data, related by crossing symmetry, are investigated. As of to-day, the K^-p and K^+p total cross sections do not coincide in the high energy limit. The implications of such behavior are discussed. It is then assumed, in accordance with theoretical models, that the two do, nevertheless, converge at energies higher than those accessible to experiment. Under this assumption, a once subtracted dispersion relation is used. The hyperon pole residues are obtained from SU(3) symmetry, the known $NN\pi$ coupling, and $F/D = 1/2$. The real part of the scattering amplitude is fairly well known only for low energies. There is almost no structure in the K^+N data. The low energy $\bar{K}N$ parameters were recently determined by several experimental groups. Whatever dependence the results may have on a specific choice of the parameters is indicated. Only the "strong" part of the $\bar{K}N$ interaction is analyzed, and attention is concentrated on the relatively well known low energy region between the $\bar{K}N$ threshold and the Y_0^* (1520) resonance. First, a straightforward extension of the Dalitz–Tuan S-wave zero-effective-range formalism is used to account for the unphysical region below the $\bar{K}N$ threshold. This results in a large but almost constant, energy independent, discrepancy between the predictions of the dispersion relation and the experimental amplitudes. Such a discrepancy could be removed by assuming the need for a second subtraction. This is an unattractive result in view of notions of particle-antiparticle symmetry. Alternatively, the unphysical region is represented by two poles, representing the Y_1^* (1385) and Y_0^* (1405). In such a model the Y_0^* pole residue has to be more than three times larger than what is expected from an SU(3) singlet assignment and the width of the $Y_0^* \to \Sigma\pi$ decay. Such conclusion gains support from an investigation of the continuation of the Dalitz–Tuan formalism into the unphysical region. The question of the $\Lambda N\bar{K}$ coupling was also considered in view of recent arguments that it is much smaller than what SU(3) symmetry predicts. However, the ambiguity in the low-energy $\bar{K}N$ parameters does not

allow any definite conclusion about this coupling from the model. Two theoretical models in which large breaking in the Y_1^* BP couplings may result are also given. The first is a four-channel Schrödinger-type semi-relativistic calculation, based on a vector meson exchange interaction. In this model the Y_0^* is a Dalitz–Tuan type virtual bound state in the $\bar{K}N$ system, and its location relative to the four BP I = Y = O channel thresholds causes the breaking. The techniques of the algebras of currents are used. In the "group-theoretical limit" there results a breaking in the Y_0^* couplings proportional to the mass differences $m_{Y_1^*} - m_{B_i}$, i = 1,2,...,8. Some corrections to this result are considered, but it is found that these do not constitute an improvement on the group theoretical limit. (Disser. Abstr.)

3448 ANALYTIC HELICITY AMPLITUDES AND REGGE-POLE FORMULAE FOR DIFFERENTIAL CROSS SECTIONS. Wang, Ling-lie Chau. Berkeley, Calif., Univ. of California, 1966. 58p.
Thesis.

A simple and straightforward method to identify and remove the kinematic singularities of helicity amplitudes is constructed from the Trueman–Wick crossing relations. A set of amplitudes free of all kinematic singularities and zeros is obtained for two-particle → two-particle reactions of any spin and masses except for boson-fermion interactions. It is shown that for boson-fermion interactions with general mass assignments there is always a kinematic $S^{\frac{1}{2}}$ singularity left in the amplitude. Therefore it is natural to consider the amplitudes of boson-fermion interactions as bunctions of $S_{\frac{1}{2}}$ instead of S. The amplitudes obtained by the above method are suitable for Reggeization and their residue functions are free of kinematic singularities. Regge pole formulas for differential cross sections of some quasi two-body πN and NN interactions, which can have one or two meson trajectories exchanged, are given. The reactions treated are: $\pi N \to \pi\Delta$ (1236), $\pi N \to \omega N$, $\pi N \to \omega\Delta$ (1236), $\pi N \to A_2 N$, $\pi N \to \eta N$, $\pi N \to \eta\Delta$, $\pi N \to \rho N$, $\pi N \to \rho\Delta$ (1236), $NN \to N\Delta$ (1236), $NN \to NN^*$ (1500, $\frac{3}{2}^-$), $NN \to NN^*$ (1480, $\frac{1}{2}^-$). (Disser. Abstr.)

3449 MULTICHANNEL APPROACH TO HIGH ENERGY PERIPHERAL COLLISIONS. Williams, Philip Karl. Bloomington, Ind., Indiana Univ., 1966. 116p.
Thesis.

In the peripheral model for high energy (>1 BeV) two-body inelastic collisions of mesons and baryons, the Born approximation amplitudes are modified to take into account absorptive effects due to other open channels. This is done to reduce the partial-wave amplitudes, which may otherwise exceed absolute limits, imposed by unitarity, especially in the lower partial waves. Each off-diagonal element of the collision matrix is estimated in terms of the Born approximation amplitude and elastic scattering parameters, using a formula applied previously. The limit of diffraction scattering is assumed for the elastic amplitudes, except when the elastic scattering is influenced in an intermediate state by the formation of a resonance. In the limit of diffraction-elastic scattering, the optical theorem yields a set of equations that are sufficient to determine all the elastic-scattering parameters. Resonances in the elastic scattering are handled phenomenologically. Thus, angular distributions are obtained for elastic scattering as well as the modified inelastic angular distributions. This procedure differs from that previously used when experimental elastic differential cross sections were used to obtain the absorption parameters. The model is formulated for spinless particles and for particles with spin. The analysis is performed for the case with spin using helicity amplitudes. The model is applied to pion–nucleon scattering in the few BeV range and the results of the calculations are compared to experiment. Finally, the asymmetric decay angular distribution of the neutral rho-meson is investigated under the assumption that a scalar-isoscalar dipion overlaps in mass with the rho-meson and can interfere with its decay. (Disser. Abstr.)

3450 PION–NUCLEON SCATTERING IN THE P_{11} STATE. Schwarz, John Henry. Berkeley, Calif., Univ. of California, 1966. 59p.
Thesis.

The P_{11} pion-nucleon scattering amplitude is studied in order to determine the dynamical status of the nucleon. A simple one channel static model is constructed in which a good fit to the low energy data is obtained with a CDD pole. If there is, in fact, such a pole, with the strength indicated by the model, then one must conclude that other channels play a significant, although not overwhelming, part in forming the nucleon. It is also possible to reconcile all the available information with a model containing no CDD poles in which the nucleon is formed to a good approximation in the pion-nucleon channel alone. A few ways by which one may hope to choose between the two models are discussed. It is shown how the success of certain "reciprocal bootstrap" calculations can be understood, whether or not a CDD pole is required. The large inelasticity and phase shift in the P_{11} pion-nucleon channel at energies of 400–600 MeV are probably due to coupling with the ππN channel, with all three particles in relative s-waves. This latter channel seems to be significant for the properties of the 1400 MeV (Roper) resonance, but probably plays a small role in the formation of the nucleon. (Disser. Abstr.)

3451 STUDY OF THE BARYON RESONANCES. Brudnoy, David Michael. Minneapolis, Univ. of Minnesota, 1966. 124p.
Thesis.

It is shown that in processes in which high spin resonances appear, the usual method of calculating with an explicit propagator function becomes most cumbersome due to the length of the propagator function for higher spin. Constructing the Rarita-Schwinger wave functions explicitly and using them in the definition of the propagator, $\sum_m u_j^{(m)} \bar{u}_j^{(m)}$, removes much of the difficulty in properly handling the various spin and kinematic factors in calculating resonance transition amplitudes and decay widths. In particular the cases of elastic meson-nucleon and photo-pion production resonance reactions are extremely simple to calculate due to the small number of terms needed to describe these reactions. The phenomenological coupling constant coupling resonance to meson and nucleon can be calculated from the experimental width of the resonance. These may then be used as a test whether or not the resonance belongs in some higher symmetry group such as SU3; this was exemplified in the case of the two $F_{\frac{5}{2}}$ resonances, the $N_{\frac{5}{2}}^*$ (1688) and the Y_1^* (1815). The two electromagnetic coupling constants are not so easily evaluated, even within the framework of this simple isobar model, because generally there is a nonnegligible interference between resonant and nonresonant parts in the angular distribution data. However within a nucleon resonance model that was constructed, these electromagnetic constants can be evaluated as a function of the resonance spin only. This model, which treats the resonance as a pion and nucleon bound in a (central) potential, $V(\vec{x}) = -V_0 + \frac{1}{2} k \vec{x}^2$, whose wave function obeys a Klein-Gordon equation, predicts a linear dependence of M_J^2, M_J the mass of the resonance, on J, the resonance spin. This prediction seems reasonably satisfied for lower-lying resonances, i.e., those resonances now presently known. Even if the nucleon resonances will not continue to be created with arbitrarily increasing mass (as $J^{\frac{1}{2}}$), due, presumably, to the centrifugal barrier, this model may still be of some use in the higher energy region. One may approximate partial wave amplitudes in that region by resonance amplitudes by formally extending those results previously mentioned, i.e., one may write $a_j(w)$ as a $\frac{1}{j^{\text{res.}}}$ ($w = J^{\frac{1}{2}}$). This resonance approximation procedure was used for the Fubini sum rule relating the anomalous magnetic moment of the nucleon to a sum over photo-pion production amplitudes. From the resulting series, an upper limit on the partial decay width of resonance into meson and nucleon was obtained. (Disser. Abstr.)

Strong (Baryon No. ≥ 2)

Refer also to abstracts 3309, 3310, 3339, 3419, 3424, and 3448.

3452 (INP-555/PL/PH, pp 75-8) WHAT ARE FIREBALLS? Miesowicz, M. (Institute of Nuclear Research, Krakow (Poland)).

The phenomena associated with the use of the fireball model for high-energy nucleon-nucleon collisions are discussed. (L.B.S.)

3453 (INP-555/PL/PH, pp 117-22) IS A HYPERISOMER OF ^{7}Li POSSIBLE? Pniewski, J.; Szymanski, Z. (Institute of Nuclear Research, Warsaw (Poland). Warsaw Univ. (Poland)); Davis, D. H. (University Coll., London (England)); Sacton, J. (Brussels Univ. (Belgium)).

An asymmetry was previously observed in the experimental λ-particle binding energy distribution for ^{7}Li. The question of whether it is possible to consider the existence of a ^{7}Li-hyperisomer as responsible for the low Λ-hyperon binding energy events is discussed. It is concluded that the energy of the $\frac{5}{2}^+$ level in ^{7}Li and therefore the existence of the isomeric state may depend significantly on the presence of tensor and spin-orbit forces in the interaction of a Λ^0-particle with nucleons. (L.B.S.)

3454 (TH-212) COVARIANT THEORY OF PION-DEUTERON ELASTIC SCATTERING. Schiff, D.; Tran Thanh Van, J. (Paris Univ., Orsay (France). Laboratoire de Physique Theorique et Hautes Energies). Aug. 1967. 64p. Dep.

The elastic pion deuteron scattering is studied in a fully covariant theory in which special attention is given to the treatment of inelastic unitarity. From a study of the box diagram singularities, the leading contributions are found to come from the impulse graphs, i.e., the two-pion exchange in the t channel and the nucleon–nucleon and the pion–nucleon–nucleon intermediate states in the s channel. The πNN state is approximated by an NN*

state and the instability of N* is taken into account. The correction terms are due to the binding, multiple scattering and absorption processes. These effects were calculated and dispersion relations for the partial wave amplitudes are used. A detailed comparison with experiments for pion energy in the laboratory system at 85, 142, 300 and 325 MeV shows an excellent agreement. (auth)

3455 CONTRIBUTION OF MANDELSTAM BRANCH CUTS TO PROTON–PROTON SCATTERING AND TO PRODUCTION AMPLITUDES AT HIGH ENERGY. Dunne, S. A. (Ioffe Inst. of Physics and Tech., Leningrad). Phys. Rev. Lett., 19: 1299-1302(Nov. 27, 1967).

The contribution of Mandelstam branch cuts to the processes $p + p \rightarrow p + p$, $p + K \rightarrow p + K^*$, $\gamma + p \rightarrow p + \pi$, and $p + \pi \rightarrow p + A_2$ is investigated by considering the structure of diagrams in which two or more Reggeons (asymptotic Regge-pole amplitudes) are exchanged. Three or more Reggeons are required for the forward nucleon-nucleon scattering amplitude $\sigma_x^{(1)}\sigma_x^{(2)} + \sigma_y^{(1)}\sigma_y^{(2)}$, and for the forward production amplitudes. These amplitudes are expected to behave asymptotically as $s/(\ln s)^3$. (auth)

3456 COMPARISONS BETWEEN ON-SHELL AND OFF-SHELL METHODS FOR THE TWO-BODY T-MATRIX. Wong, D. Y. (Univ. of California, San Diego, La Jolla). pp 49-55 of Elementary Particle Physics. Takeda, Gyo; Fujii, Akihiko (eds.). Tokyo, Syokabo Publishing Co. and New York, W. A. Benjamin, Inc., 1967.

The nonrelativistic Low equation is extended to include the relativistic phase space factor. A general velocity dependent potential is also allowed. A method for solving the Low-equations is derived and applied to the NN, $N\bar{N}$, and $\pi\pi$ scattering problems. The results are compared with solutions of the on-shell N/D equations. It is found that the off-shell method does not alter significantly the results of semi-phenomenological on-shell calculations except in the case when there are strongly bound states. (L.B.S.)

3457 PLOT OF ALL HIGH-ENERGY p–p ELASTIC SCATTERING DATA USING PARTICLE IDENTITY. Krisch, A. D. (Univ. of Mich., Ann Arbor). Phys. Rev. Lett., 19: 1149-51 (Nov. 6, 1967).

Previous attempts to find a single variable against which all cross sections for proton-proton elastic scattering could be plotted in an energy-independent way are briefly summarized. It is proposed that the flattening observed near 90° in a recent plot of $d\sigma/dt$ against $\beta^3 P_\perp^2$ (β is the center-of-mass velocity and $P_\perp$ is the transverse momentum) is caused by the fact that the system contains two identical particles. The cross section is studied when identity effects are subtracted out. A single smooth curve was obtained over a cross-section range of 10^{12}. (L.B.S.)

3458 NUCLEON–NUCLEON SCATTERING. Breit, G.; Haracz, R. D. (Yale Univ., New Haven). Contract AT(30-1)-1807. pp 21-191 of High Energy Physics. Vol. I. Burhop, E. H. S. (ed.). New York and London, Academic Press, 1967.

Some progress in the field of nucleon-nucleon scattering is reviewed in section I. Section II deals with the meaning of phase shift, the concept being introduced directly in a relativistic manner. In Section III the scattering matrix is discussed in terms of explicit formulas involving phase shifts and coupling parameters. The transition from the magnetic quantum number representation to one involving spin functions transforming under rotations like Cartesian coordinates is explictily presented for the scattering as well as the density matrices. In section IV the calculation of quantities measured in experiments is discussed with results usually stated in two equivalent forms. Some references to work on polarized proton sources are also included. Section V is concerned with relativistic kinematics and with some relativistic electromagnetic effects. Section VI deals with the one pion exchange interaction assuming pseudoscalar coupling. The lack of a firm foundation for the localization of OPE effects is discussed. In addition, some usually omitted Coulomb effects are mentioned which may have an influence on the values of the pion-nucleon coupling constant derived from data analysis. In section VII the procedures used in searching for phase shifts giving the best fits to experimental data are discussed. Section VIII begins with a discussion of the conclusion reached by Noyes to the effect that the effective range of the $^1S_0$ state is about 10% smaller for n-p than for p-p scattering. Section VIII-B deals with the laboratory energy region from about 10 to 350 MeV. A brief account is given of phase shift analyses above the meson threshold production and of the way in which it joins on to the intermediate region in section VIII-C. A very brief account is also given of typically high energy phenomena in the region of several BeV and of some of the existing theoretical explanations. Section IX is concerned with the empirical evidence that has accumulated from partial wave data analyses concerning charge independence at large distances. A brief account is also given of empirical tests of the mathematical form of the OPEP. In section X a few remarks are made regarding the present status of the theory and test of space-time symmetries of nucleon-nucleon interactions. (417 references with supplementary references added in proof). (L.B.S.)

3459 EFFECT OF THREE-BODY ΛNN LONG-RANGE POTENTIAL IN NUCLEAR MATTER. Bhaduri, R. K.; Loiseau, B. A.; Nogami, Y. (McMaster Univ., Hamilton, Ont.). Nucl. Phys., B3: 380-6(1967).

The effect of the two-pion-exchange ΛNN force on the binding of a Λ in nuclear matter is considered using perturbation theory. It is pointed out that the contribution of the dominant noncentral part of the ΛNN potential to B_Λ is extremely sensitive to nucleon-nucleon (NN) correlation. The long-range part of the ΛNN force (for ΛN distances >0.6 fm) gives a repulsive contribution of a few MeV, but this number can not be predicted unless the NN correlation function is accurately known. (auth)

3460 PION CHARGE-EXCHANGE SCATTERING ON NUCLEI AND PROTON–NEUTRON CORRELATIONS. Eisenberg, J. M. (Univ. of Virginia, Charlottesville). Nucl. Phys., B3: 387-94(1967).

Theoretical aspects of the $(\pi^\pm,\pi^0)$ reaction in complex nuclei are studied using the impulse approximation and the Chew–Low amplitude for pion-nucleon scattering. Sum rules are developed for the differential cross section integrated over the final pion energy. It is shown that this quantity is sensitive in particular to proton-neutron correlations in the nucleus and thus its measurement may provide useful information on one aspect of nucleon-nucleon correlations. Expressions are presented for the energy-integrated cross section for closed shell or closed subshell nuclei. Numerical results are given in the case of ^{16}O, where it appears that correlations due to the Pauli exclusion principle are far more significant than those due to the nucleon hard core. (auth)

3461 INTERACTIONS AT VERY HIGH ENERGIES. Kidd, J. M. (Univ. of Bristol, Eng.). pp 265-302 of High Energy Physics. Vol. II. Burhop, E. H. S. (ed.). New York and London, Academic Press, 1967.

The characteristics of nucleon-nucleon and nucleon-nucleus collisions are briefly reviewed at accelerator and cosmic ray energies. The isobar model of high-energy interactions is examined as a possible explanation of some observed properties of very high energy interactions and as a basis for the comparison of other explanations and models. (L.B.S.)

3462 HYPERNUCLEAR PHYSICS. Davis, D. H. (London Univ.); Sacton, J. pp 365–455 of High Energy Physics. Vol. II. Burhop, E. H. S. (ed.). New York and London, Academic Press, 1967.

A review is given of the theoretical and experimental studies in hypernuclear physics. The detection, analysis and production of hypernuclei are first discussed. Other topics covered include the binding energies of light hypernuclei; hypernuclear spins; nonmesonic decays; π^0-mesonic decays, π^--mesonic decays, and leptonic decays; life-times of hypernuclei, the Λ-nuclear potential and the Λ–Λ interaction; and hypernuclei and nuclear physics. (~225 references). (L.B.S.)

3463 COHERENT PRODUCTION OF RESONANCES ON DEUTERIUM AT HIGH ENERGIES. Bertocchi, L. (CERN, Geneva); Caneschi, L. Nuovo Cim. (10), 52A: 295-300(Nov. 1, 1967).

It is pointed out that the measurement of the angular distribution in the processes meson (π) + He-4 → meson + He-4 and p + He-4 → baryon + He-4 cannot give a good determination of a third parameter of the process, the width of the forward elastic peak, while this width can be determined from the corresponding reaction on the deuteron. The process $\pi + d \rightarrow \rho + d$ is calculated. (J.F.P.)

3464 BETHE'S FORMULA FOR COULOMB-NUCLEAR INTERFERENCE. Islam, M. M. (Brown Univ., Providence). Contract AT(30-1)-2262. Phys. Rev., 162: 1426-9(Oct. 25, 1967). (NYO–2262TA-149).

Approximations involved in the deduction of Bethe's formula for Coulomb-nuclear interference are reexamined. Some corrections to the formula are obtained by improving the approximations. It is, however, expected that these corrections are small. (auth)

3465 OPTICAL-MODEL ANALYSIS OF PION-NUCLEUS SCATTERING. Auerbach, E. H. (Brookhaven National Lab., Upton, N. Y.); Fleming, D. M.; Sternheim, M. M. Phys. Rev., 162: 1683-94(Oct. 25, 1967). (BNL–11498).

Determination of nuclear-density parameters and of the rms pion charge radius r_π from the elastic scattering of pions by nuclei

has been studied using the optical model proposed by Kisslinger. Good fits to the available data in the kinetic-energy region 24 MeV ≤ T_π ≤ 153 MeV have been found by searching the parameter space. For $T_\pi \approx 80$ MeV, i.e., T_π large compared to nuclear binding energies but well below the N^* resonance, the best-fit parameters are close to those predicted from pion-nucleon phase shifts. The nuclear radii obtained are consistent with electron-scattering radii; the calculated differential cross sections are sensitive to a second nuclear-density parameter for large angles. "Distortion" of the Coulomb amplitude in 24-MeV π^4-α scattering reduces r_π from 1.8 ± 0.8 F to $r_\pi \leq 2.0$ F (two standard deviations), in agreement with West's recent calculation. (auth)

3466 ELASTIC NUCLEON–DEUTERON SCATTERING WITH TENSOR INTERACTION. Purrington, Robert Daniel. College Station, Tex., Texas A and M Univ., 1966. 82p.
Thesis.

The theory of low energy elastic nucleon-deuteron scattering in the presence of a tensor force was developed using the Born approximation, with modification. The angular distributions were calculated for elastic neutron-deuteron scattering at energies from 0.99 MeV to 22 MeV and were found to differ little from the central force calculations. The theory of polarization in nucleon-deuteron scattering was given in some detail and numerical results obtained for the polarization of the scattered nucleon in the energy range 0.99 MeV to 22 MeV. The results show substantial qualitative agreement with experiment and permit some conclusions to be made about the deuteron D-state admixture. (Disser. Abstr.)

3467 VELOCITY DEPENDENT BOSON EXCHANGE POTENTIALS AND NUCLEON–NUCLEON SCATTERING IN THE BORN APPROXIMATION. Sharma, Ravi Dutta. Gainesville, Fla., Univ. of Florida, 1966. 295p.
Thesis.

An attempt was made to understand the nucleon-nucleon (NN) interaction in terms of the one-boson-exchange-potential (OBEP) model and to account for NN elastic scattering phase-shifts in the Born approximation for nonrelativistic energies (25–310 MeV) in the laboratory frame. Theoretically, the OBEP are derived by Green, the resulting expressions being given in the Diracian form. The two-particle Dirac equation is reduced to a Schrodinger-Pauli form using a method similar to Breit's method of reduction to large components. A general form of interaction is then obtained in the Pauli-form which is applied to scalar, pseudoscalar and three different forms of vector meson exchange potentials. The Schrodinger-type equation with velocity dependence can be treated by the method of effective mass generally used in exact treatments. Another possible method in the Born-approximation is the direct-method which can treat the velocity dependence directly in phase-shift integrals without going to an effective potential. The experimentally known mesons π, ω, ρ and η are used together with two postulated scalar mesons in Green's purely relativistic model (cancellation of static scalar vector terms) as well as in broken-relativistic models and use is made of modified Yukawa form with a higher mass subtractive meson coming from Green's work on generalized Lagrangian. This removes the singularities from the integrands and parameterizes the OBEP in the inner regions where it is uncertain. The scalar meson masses are very important for the results presented in this study on phase shifts. Only phases higher than S-waves are considered. The Born phases are found to be quite reliable for D-waves and higher and can be corrected empirically for P-waves. The Born-approximation generally gives larger P-wave results. Comparisons are made for certain sets of parameters between exact and Born phases and the differences are large only for the P-waves. Coupled states are treated according to Stapp's formalism and are also found to conform to these conclusions. Three different vector meson interactions are treated and Born phases resulting from them indicate that their relativistic terms agree for P-waves and higher. Various theoretical questions should be resolved before treating the S-waves, for which these interactions are likely to differ. The effective mass method is shown to break down if ρ meson parameters play an important role. The Born approximation, direct method, can help in that case and also the effects of various mesons and various terms in the interactions can be seen more explicitly in the Born approximation. A more correct treatment of the problem would require an exact relativistically correct treatment. Two pion exchange interactions as well as other processes like pair production, etc., should be considered for correct treatment of the S-waves. (Disser. Abstr.)

3468 ANALYSIS OF THE ELASTIC SCATTERING OF PROTONS AT HIGH ENERGY AND MOMENTUM TRANSFER USING THE SERBER MODEL AND BAKAMJIAN–THOMAS THEORY. Avison, David. Providence, Brown Univ., 1966. 90p.
Thesis.

Serber's model for describing proton-proton scattering is investigated in detail at two laboratory momenta, 11.26 and 30.0 GeV/c, by carrying out a partial-wave computation with the potential $A = (A_\phi, \vec{A}) = (i\eta e^{-\Delta r}/r, 0, 0, 0)$ inserted into the Klein-Gordon equation $[(p_{op}-A)^2 + m^2]\psi = (E - A)^2\psi$. The two resulting momentum-transfer distributions obtained differ from those obtained by Serber, who used an optical approximation. Both curves are raised above Serber's in the high momentum-transfer region. This causes the 11.26 GeV/c curve to be in better agreement with the data and the 30.0 GeV/c curve to "overshoot" the data yielding worse agreement. The rising of these momentum-transfer curves in the high momentum-transfer region is due to the appearance of a real part in the low angular-momentum contributions to the scattering amplitude. The Bakamjian-Thomas theory is used to obtain relativistic scattering equations for the relative motion. These are presented in a squared and in an unsquared form and both forms are realized in Cartesian coordinates and reduced to partial wave equations for the case of an isotropic potential dependent only on the B.-T. relative coordinate. These equations are shown to bear a resemblance to the Klein-Gordon equation with Serber's potential A. The first Born approximation of the scattering amplitude as computed from the Bakamjian-Thomas equations and from the Klein-Gordon equation are shown to agree as $k \to \infty$. Differences between these approaches are expected to show themselves mainly at large-angle scattering since the (unsquared) Bakamjian-Thomas Green's function differs appreciably from that of the Klein-Gordon equation only for small r. (Disser. Abstr.)

Particle Invariance Principles and Symmetries

General

Refer also to 3761.

3469 (CERN–67-24(Vol.1)) PROCEEDINGS OF THE 1967 CERN SCHOOL OF PHYSICS, RAETTVIK, MAY 21–JUNE 3, 1967. VOLUME I. Nilsson, Jan; Jacob, Maurice (European Organization for Nuclear Research, Geneva (Switzerland)). Sept. 15, 1967. 162p. Dep.

There were two lectures included. Separate abstracts were prepared for both lectures. (J.F.P.)

For abstracts of individual lectures see: 3470 and 3483.

3470 (CERN–67-24(Vol.1), Paper 1) THE DISCRETE SYMMETRIES: P, C, AND T. Nilsson, Jan (Goteborg Univ. (Sweden). Inst. of Theoretical Physics). 119p.

The discussion of the discrete symmetries includes a brief review of the basic formalism and invariance principles, then space reflection and parity, charge conjugation and charge parity, the CP and CPT transformations, and time reversal are considered. Predictions which follow from more than one invariance principle, and the concept of symmetry in the presence of symmetry-violating interactions are also discussed. (J.F.P.)

3471 QUANTIZABLE CLASSICAL MODELS FOR ELEMENTARY PARTICLES. Souriau, Jean-Marie (Faculte des Sciences, Marseille). Compt. Rend., Ser. A and B, 265: 165-7 (July 17, 1967). (In French).

The symplectic cohomology of a Lie group and the symplectic varieties associated with Lie groups are given. There is available a very general algorithm to construct unitary representation of the Lie groups. The models are applied to nonrelativistic elementary particles. The model proposed does not coincide with the geometric optics approximation. It is only by neglecting j that classical concepts are attained. By making $j = \hbar/2$, a quantizable model is obtained that gives a nonrelativistic description of the neutrino. (J.S.R.)

3472 SUM RULE FROM ω-φ MIXING AND ASYMPTOTIC VALIDITY OF SU_3. Dietz, K.; Pietschmann, H. (Univ., Bonn). Nuovo Cim. (10), 52A: 631-4(Nov. 21, 1967).

The assumptions that internal symmetries become exact in the asymptotic region together with the assumption of dominance of low-mass states is further elaborated. To do this ω-φ mixing is assumed as an explicit mechanism that breaks the SU(3) symmetry. (J.F.P.)

3473 UNITARY SYMMETRY. Matthews, P. T. (Imperial Coll. of Science and Tech., London). pp 391-481 of High Energy Physics. Vol. I. Burhop, E. H. S. (ed.). New York and London, Academic Press, 1967.

A comprehensive treatment is presented on the theory and application of unitary symmetry. Following a brief discussion on invariance and unitary transformations, the following topics are treated: baryon conservation–U(1); isotopic spin–SU(2);

hypercharge and SU(3); space-time and SU(6); Lorentz invariance; and covariance and U(6,6). The most important new emphasis is on the technique of finding the particle multiplets by explicit construction from the basic spinors, suitably symmetrized or antisymmetrized. A brief general discussion is given in Appendix B, and by way of illustration, they are used to derive some well known results for isotopic spin multiplets. A very brief summary of the main group theoretical ideas which are being used is given in Appendix A. (50 references). (L.B.S.)

3474 CONFORMAL-GROUP ALGEBRA AND ITS UNITARY REPRESENTATION IN THE SPACE OF HARMONIC FUNCTIONS. Maduemezia, Awele (International Atomic Energy Agency, Trieste, Italy). Nuovo Cim. (10), 51A: 932-48(Oct. 21, 1967).

The equations of Killing establishing the group $SO_{4,2}$—the conformal group—as the group of motions of the 5-dimensional pseudosphere $|\psi_1|^2 + |\psi_2|^2 - |\psi_3|^2 = |\psi_4|^2 = 1$, $\psi = (\psi_1, \psi_2, \psi_3, \psi_4) \in C^4$, are explicitly solved in spherical co-ordinates. The 15 most natural generators of the conformal group, in terms of which the maximal compact subgroup factors out, are thereby realized in terms of the natural co-ordinates of this space. In terms of these generators, the generators of the Poincaré group plus dilatations are explicitly written. It is shown that the mass-squared operator $p_\mu p^\mu$ is not diagonal in the (irreducible) representation of the conformal group in the Hilbert space of harmonic functions defined on a 5-dimensional pseudosphere. The restriction of this representation to the Poincaré group is therefore not irreducible. (auth)

3475 LOCAL DYNAMICAL SYMMETRIES OF CLASSICAL SYSTEMS. Duimio, F. (Univ., Milan. Istituto Nazionale di Fisica Nucleare, Milan); Pauri, M. Nuovo Cim. (10), 51A: 1141-50(Oct. 21, 1967).

A qualitative discussion is presented on the symmetry degeneracy problem in classical mechanics. A simple and general technique is reported for the construction of the local compact groups of symmetry SU_n and O_{n+1}, which are admitted by any completely degenerate bounded classical system with n degrees of freedom. (L.B.S.)

3476 NOTE ON SU_3 WIGNER COEFFICIENTS. Di Leva, A.; Ponzano, G. (Univ., Turin). Nuovo Cim. (10), 51A: 1107-18 (Oct. 21, 1967).

Particular cases of SU_3 vector coupling coefficients are calculated; the general nonorthonormalized (n.o.n.) isoscalar factor is evaluated in terms of SU_2 21j-symbols. (auth)

3477 CAUSALITY GROUP. Barucchi, G. (Univ., Turin); Teppati, G. Nuovo Cim. (10), 52A: 50-61(Nov. 1, 1967).

The causality group C_{n+1}, $n \geq 1$, introduced by Zeeman, is examined. The group C_2 is studied first. By means of elementary geometrical arguments, which make evident the difference between the cases $n = 1$ and $n > 1$, it is then proved that the elements of C_{n+1}, $n > 1$, are linear. In particular the Zeeman theorem is proved again in a new simpler way. By introducing particular co-ordinate axes it is shown that any element of the group C_{n+1}, $n > 1$, is the composition of an element of the group C^*_{n+1} and an element of the group C'_{n+1}. C^*_{n+1} is the subgroup of $(D\uparrow)_{n+1}$ ($(D\uparrow)_{n+1}$ being the group any element of which is the composition of an element of the orthochronous Poincaré group, $(P\uparrow)_{n+1}$, and an element of the group of the positive dilatations, R^+_+, i.e. the multiplicative group of positive real numbers) the elements of which do not change the value of the time co-ordinate x_{0A} of any point A. C'_{n+1} is the subgroup of $(D\uparrow)_{n+1}$, which has no common element with C^*_{n+1} except for the identity permutation. It is shown that C'_{n+1} is the direct product of $n + 1$ of its particular subgroups. (auth)

3478 CURRENTS AND SYMMETRY BREAKING. Levy, M. (Univ., Paris). Nuovo Cim. (10), 52A: 23-49(Nov. 1, 1967).

A field-theoretical model is discussed, in which a fermion triplet field is coupled to pseudoscalar, scalar, vector and axial vector meson nonets. A symmetry-breaking mechanism is introduced by postulating that some of the vacuum expectation values of the scalar field operators do not vanish. The currents satisfy broken partial-conservation equations which agree with the postulates of the Cabibbo theory of weak interactions. They generate also, even when the Lagrangian is not invariant, a full $SU_3 \times SU_3$ algebra. In order to induce a meson mass breaking, the existence of a non-linear meson-meson interaction plays an important role. The observed values of the pseudoscalar meson masses enable one to calculate most of the meson-meson coupling constants and, then, to predict the masses of the scalar mesons. (auth)

3479 EXTENSION THEOREM AND MAJORANA REPRESENTATION. Sankaranarayanan, A. (Ames Lab., Iowa. Douglas Advanced Research Labs., Huntington Beach, Calif.). Contract W-7405-eng-82. Nuovo Cim. (10), 52A: 91-106(Nov. 1, 1967). (IS-1582).

Some unitary irreducible representations of the Lorentz group $O_{3,1}$ are constructed from the inhomogeneous rotation group IO_3 and they are of the form $(h,0)$ where h is either a nonnegative integral or a half-integral number. From these representations the now well-known Majorana representation $(\frac{1}{2},0)$ of $O_{3,1}$ corresponding to the Casimir invariant values $C_1 = -\frac{3}{4}$ and $C_2 = 0$ is deduced. It is shown that a set of 4 Hermitian matrices transforming as a four-vector under the $(h,0)$ representations of $O_{3,1}$ exists only for $(\frac{1}{2},0)$ and these four-vector matrices with the $(\frac{1}{2},0)$ of $O_{3,1}$ form a unitarity irreducible representation of the De Sitter group $O_{3,2}$ corresponding to the Casimir-operator values $C_1 = -\frac{5}{4}$ and $C_2 = 0$. Thus, a link among the "nonrelativistic" IO_3, "relativistic" $O_{3,1}$ and the "cosmological" $O_{3,2}$ in an ascending fashion is established. (auth)

3480 TWO WAYS OF SPONTANEOUS SYMMETRY BREAKING. Maris, Th. A. J.; Jacob, G.; Liberman, B. (Univ. Federal do Rio Grande do Sul, Porto Alegre, Brazil). Nuovo Cim. (10), 52A: 116-21(Nov. 1, 1967).

A distinction between two types of spontaneous symmetry breakings is made: "asymptotical" breaking and "local" breaking. The former is characterized by a conserved symmetry current and by the presence of Goldstone bosons (or long-range interactions), and occurs in the BCS-theory as well as in classical theories. For local breakings the usual proof of current conservation breaks down as a result of the singularity of a product of field operators at one point, as occurring in currents and their divergences. This case is realized in certain local quantum field theories, e.g. in quantum electrodynamics with zero bare mass. Local breakings, in contradistinction to asymptotical ones, might be useful in a field theory of elementary particles. (auth)

3481 NONINVARIANCE GROUPS IN PARTICLE PHYSICS. Kuriyan, Jacob G. (Syracuse Univ., N. Y. Inst. for Advanced Study, Princeton, N. J.); Sudarshan, E. C. G. Contract AT(30-1)-3399. Phys. Rev., 162: 1650-62(Oct. 25, 1967). (NYO-3399-195).

The concept of a noninvariance group is introduced by considering some classical systems. This is then used to study properties of strongly interacting particles. A logically consistent way of deriving static properties such as magnetic moments and electromagnetic mass differences, as well as predictions regarding scattering cross sections, is described. (auth)

Applications (Electromagnetic and Weak)

Refer also to abstracts 3352, 3358, 3471, 3500, and 3702.

3482 (CERN-66-29(Vol.3), pp 1-92) STATUS OF FUNDAMENTAL SYMMETRIES AND WEAK INTERACTIONS. Tolhoek, H. A. (Groningen Rijksuniversiteit (Netherlands). Instituut voor Theoretische Fysica).

A concise review of the present status of the more "classical" selection rules of the weak interactions (concerning isospin, ΔS, etc.) and of the problems of universal Fermi interaction, lepton-conservation and intermediate boson hypothesis is given. Further, the invariance or noninvariance of weak interactions for the fundamental P, C and T transformations is examined, including a discussion of PC violation in K^0_L decay. Relations between weak interactions and the newer symmetries are not discussed. (auth)

3483 (CERN-67-24(Vol.1), Paper 2) WEAK INTERACTIONS AND HIGHER SYMMETRIES. Jacob, Maurice (Commissariat a l'Energie Atomique, Saclay (France). Centre d' Etudes Nucleaires). 36p.

An introduction is given to the consequences of higher symmetries in weak interaction processes with restriction made to the $SU(3) \times SU(3)$ symmetry group. The general properties of the weak hadronic currents are discussed, and the Adler–Weisberger relation is derived starting from current algebra. The $\pi + N$ forward elastic scattering amplitude is considered. (J.F.P.)

3484 (LPTHE-TH-204) CONSERVATION LAWS AND SELECTION RULES IN K-MESON DECAY. An Introductory Survey. Primakoff, Henry (Paris Univ., Orsay (France). Laboratoire de Physique Theorique et Hautes Energies). June 1967. 53p. Dep.

The discussion showed that the sum total of information on the decays of the K-mesons: is consistent with the CPT invariance of $H_{weak} + H_{elmag}$; is consistent with the CP invariance of $H_{weak} + H_{elmag}$ except for the presence of the decays $K^0_2 \to \pi^+\pi^-$ is consistent with the $\Delta S = \Delta Q$ rule; exhibits violation of the $I = \frac{1}{2}$ rule in the CP conserving decays $K^+ \to \pi^+ + \pi^0$ and $K^0_1 \to \pi^+\pi^-$ which appear to be larger than might be reasonably expected on the basis

of an electromagnetic origin of the violations; and exhibits relatively appreciable violations of the $\Delta I = \frac{1}{2}$ rule in the CP violating decays $K_2^0 \rightarrow \pi^+\pi^-\pi^0$, however, the $\Delta I = \frac{1}{2}$ rule violating matrix element in the CP conserving decays $K_1^0 \rightarrow \pi^+\pi^-\pi^0$ is large compared to the $\Delta I = \frac{1}{2}$ rule violating matrix element in the CP-conserving decays $K_2^0 \rightarrow \pi^+\pi^-\pi^0$. (auth)

3485 ASYMPTOTIC SYMMETRY FOR VECTOR MESONS. Bose, S. K.; Torgerson, R. (Univ. of Notre Dame, Ind.). Phys. Rev. Lett., 19: 1151-3(Nov. 6, 1967). (COO-427-70).

The electromagnetic decays of vector mesons, the $\varphi \rightarrow K\bar{K}$ decay, and the coupling constants for ω and φ baryons are calculated, assuming the asymptotic validity of the nonet symmetry. (auth)

3486 THE NATURAL HISTORY OF MESON 35 +1. Marx, Gyorgy; Toth, Kalman (Lorant Eotvos Univ., Hungary. Central Research Inst. for Physics, Hungary). Magy. Fiz. Foly., 15: 349-64(1967). (In Hungarian).

In order to understand and systematize the properties and the interactions of the more than 100 so-called elementary particles, the decay processes of the pseudoscalar and vector mesons were examined. The SU(6) system was chosen as the guiding principle for classifying the mesons in the known 35 and one-dimensional representation. The SU(3) symmetry was used in the review of the decay processes, referring the SU(6) system only if it was able to provide new information. The quantum numbers, masses, times of life and other experimental data concerning decay processes were taken from the compilation reported by A. H. Rosenfeld et al. The weak interactions of pseudoscalar mesons were classified on the basis of the final product as leptonic processes involving light particles, and nonleptonic processes, yielding only hadrons. The electromagnetic decay of the π^0 and η pseudoscalar mesons were also considered. Vector mesons were found to exhibit primarily strong-interaction type decay. It was found that weak leptonic interactions and electromagnetic processes are best understood at present; the mechanism of nonleptonic weak interactions presents as yet unsolved problems. (TTT)

3487 ELECTROMAGNETIC SIMULATION OF T VIOLATION IN BETA DECAY. Callan, Curtis G. Jr.; Treiman, S. B. (Princeton Univ., N. J.). Phys. Rev., 162: 1494-7(Oct. 25, 1967).

β-decay correlation terms of the form $J \cdot p_e \times p_\nu$ can arise, insofar as time-reversal invariance is valid, only from the influence of final-state electromagnetic interactions. For allowed transitions governed by V, A couplings, the effects are recoil-dependent. They are computed here, to lowest relevant recoil and electromagnetic orders, for the special class of spin-$\frac{1}{2}$ mirror transitions, of which the decay process $^{19}Ne \rightarrow {}^{19}F + e^+ + \nu$ is an example. On the conserved-vector-current hypothesis, the correlation effect in question is seen to be dominated by the phenomenon of weak magnetism. (auth)

3488 CP-VIOLATING INTERFERENCE EFFECTS IN RADIATIVE K^0 DECAYS. Sehgal, L. M.; Wolfenstein, L. (Carnegie Inst. of Tech., Pittsburgh). Phys. Rev., 162: 1362-8(Oct. 25, 1967).

It is shown that the observation of interference between K_L and K_S decays in the partial decay rate into any nonleptonic mode is direct evidence of CP violation. The examples of $K^0 \rightarrow \gamma + \gamma$ and $K^0 \rightarrow \pi^+ + \pi^- + \gamma$ are analyzed in detail; a large interference effect may be possible in either of these cases if there is a large CP violation associated with interactions involving photon emission. (auth)

3489 SYMMETRY-BREAKING CORRECTIONS TO THE COLEMAN-GLASHOW MAGNETIC MOMENT FORMULAE. Walsh, Thomas Francis. Berkeley, Calif., Univ. of California, 1966. 107p.

Thesis.

The problem of how are the Coleman-Glashow magnetic moment formulas altered by the SU(3) symmetry-breaking is considered. First a simple, essentially perturbation theory, model is considered for the anomalous moments in which the symmetry breaking appears when the physical masses are inserted into the propagators in the amplitude. In the symmetry limit the moments so calculated obey the Coleman-Glashow relations. When the symmetry is broken the moments depend in a complex fashion on the masses and the D/F ratio. The Coleman-Glashow relations are then altered by an amount of the same order as the mass splitting in the baryon octet. Following this, the commutator of the U-spin raising operator with the electromagnetic current is studied. A dispersion relation can be written in which the pole terms (which come from the one-particle intermediate states in the absorptive part of the amplitude) give simple relations among the anomalous moments K/2m. These relations are not the Coleman-Glashow relations and in particular the Λ^0 moment cannot be extracted. In order to find the Λ^0 moment in the pole approximation a double commutator involving the I and V spin is considered. From this commutator, in the pole approximation, relations formally identical to the Coleman-Glashow ones are found, except that the anomalous moments K/2m appear. If the continuum contributions to the dispersion relation are in fact ignorable these relations are valid even when the symmetry is broken. The problem of the continuum corrections to the pole approximation is taken in a provisional way. A simplification is effected because of the appearance of vector currents in the dispersion relation, making it possible to use the Ademollo-Gatto theorem to give the relevant form factors, at least up to first order in the symmetry breaking. One-baryon-plus-one-soft-pion states are inserted into the dispersion relation and the region near the threshold is considered. The corrections are then seen to be of first order in the mass-splitting, and in fact turn out to be about 20% for the Σ^+ moment. Then the corrections to the other relations from the U spin commutator are examined. The problem of corrections to the pole approximation for the double commutator (and in particular the corrections to the Λ^0 moment) is discussed only briefly since a much more careful inquiry is necessary there because of the necessity of preserving consistency with the corrections computed for the single commutator. The prospects for this particular sort of model appear good. (Disser. Abstr.)

3490 STUDIES ON SOME CONSEQUENCES OF ALGEBRA OF CURRENTS AND MODELS OF ELEMENTARY PARTICLES. Khanna, Mohinder Paul. Rochester, N. Y., Univ. of Rochester, 1967. 104p.

Thesis.

The algebra of currents was used to deduce some of the consequences of the conventional symmetry groups. It is shown first that for the SU(6) and the SU(4) algebras generated by currents, a consistent solution for the matrix elements of the currents is obtained only for the states at rest. It is then shown that if, instead, the algebra of the group $SU(6)_w$ is employed, one is able to get the SU(6) symmetry results for the axial vector coupling constant and the d/f ratio, working with states with arbitrary but collinear momenta. In this manner the well-known SU(6) results for the electric form factor of the nucleon were derived, besides obtaining a relation between the axial vector form factor, the induced pseudoscalar form factor and the electric form factor. Starting out with a suitable commutator, the spectacular result of the SU(6) symmetry for the ratio of the magnetic moments of the proton and the neutron was also obtained. Finally, using the technique of Fubini and Furlan and following a method developed by Kawarabayashi and Suzuki, a determination of the $\omega-\phi$ mixing angle was made in good agreement with the generally accepted value. Consideration of the equal time commutators of the components of the electromagnetic current is given with a view to test the validity of various field-theoretic models of elementary particles. The SU(3) symmetry, which is known to be valid to a good approximation for the strong interactions, finds a simple explanation in terms of a number of models of elementary particles. Okubo has, however, noted recently that the equal-time commutation relations of the space components of the electromagnetic current are model-dependent and, therefore, may give rise to different results. Hence, these commutators may be employed to discriminate between various models. Use was made of these commutation relations to calculate the β-decay axial vector coupling constant g_A, and also the rate for the decay $\pi^0 \rightarrow 2\gamma$. The results depend rather sensitively on the particular model employed. Through comparison with the experimental data, it is concluded that the Gell-Mann Zweig model may be preferred over the other models discussed here. (Disser. Abstr.)

Applications (Strong)

Refer also to abstract 3442.

3491 POLARIZATION OF RESONANCES IN A SIMPLE PERIPHERAL SU/sub 6w/ MODEL. Doncel, M. G. (Centre de Physique Theorique de l'Ecole Polytechnique, Paris. Institut des Hautes Etudes Scientifiques, Bures-sur-Yvette, France). Nuovo Cim. (10), 52A: 617-27(Nov. 21, 1967).

A simple generalization of the peripheral $SU(6)_W$-invariant model, which can be applied to interactions of the type: pseudoscalar meson + nucleonid octet → vector meson + nucleonid octet, and pseudoscalar meson + nucleonid octet → vector meson + decuplet baryon, is sketched. The polarization of the resonances in these interactions are predicted without any arbitrary parameters. Experimental results on the spin and isospin character of the exchanged particle are explained in a natural way. Some failures of the exact $SU(6)_W$ symmetry are understood and disappear in this model. (J.F.P.)

3492 ON THE UNITARY IRREDUCIBLE REPRESENTATIONS OF THE STRONG COUPLING GROUP $[SU_2 \otimes SU_2] \times T_9$. Kihlberg, A. (CERN, Geneva). Nuovo Cim. (10), 52A: 529-36(Nov. 21, 1967).

A method for obtaining the unitary representations of $[SU_2 \otimes SU_2] \times T_9$ is presented. Its main virtue lies in its simplicity and in the fact that the physically interesting properties of the representations are exhibited. (auth)

3493 GROUP-THEORETICAL RELATIONSHIPS BETWEEN BARYON–BARYON SCATTERING CROSS-SECTIONS. Kaiser, G. D. (Cambridge Univ., Eng.). Nuovo Cim. (10), 52A: 458-73(Nov. 21, 1967).

The unitary scalar factors for the SU_6 product $56 \otimes 56$ were calculated. Predictions about relations between baryon-baryon scattering cross sections were derived using both SU_3 and SU_6 techniques. (auth)

3494 AXIAL-VECTOR CURRENT CONSISTING OF PSEUDOSCALAR OCTET. Sugawara, Masao (Purdue Univ., Lafayette, Ind.). pp 115-26 of Elementary Particle Physics. Takeda, Gyo; Fujii, Akihiko (eds.). Tokyo, Syokabo Publishing Co. and New York, W. A. Benjamin, Inc., 1967.

The structure of the axial-vector current A_i is discussed in terms of the conventional field operators of the baryon and pseudoscalar octets with introducing a scalar octet. (L.B.S.)

3495 MASS OF THE D AND E MESONS UNDER ASYMPTOTIC SU(3) × SU(3). Kawarabayashi, Ken (Kyoto Univ. Ohio State Univ., Columbus); Wada, Walter W. Contract AT(11-1)-1545. Phys. Rev. Lett., 19: 1193-5(Nov. 13, 1967).

A possible assignment of quantum numbers for the D and E mesons through mass relation that results from asymptotic SU(3) in which the SU(3)-breaking effect is taken into account is discussed. It is concluded from the analysis that it is consistent to assume that A_1, K_A, and E mesons form an octet, and the D meson a unitary singlet of axial-vector mesons with the mixing angle $\theta \approx 30°$ between E and D. (J.F.P.)

3496 SU_3 27-PLET STRUCTURE OF THE $J^P = 3/2^-$ BARYON RESONANCES. Nwachuku, C. O. (International Centre for Theoretical Physics, Trieste, Italy). Nuovo Cim. (10), 51A: 1158-62(Oct. 21, 1967).

An attempt is made to establish the existence of some high-(I,Y) resonances by showing that some of the already observed low-(I,Y), $J^P = 3/2^-$ baryons possess the group structure of the $\{27\}$ of SU(3), or correspondingly, $\{700\}$ of SU(6). It is shown that the $Y_1^*(1715)$, $Y_1^*(1700)$, and $\Xi^*(1820)$ can be accommodated in the $\{27\}$. Then using the Geli-Mann–Okubo mass formula, predictions are made for the M^* (1476), N^* (1588), N^* (1612), Y^* (1748), Ξ^* (1848) and W^* (1932). (L.B.S.)

3497 CROSSING-SYMMETRIC, DYNAMICAL APPROACH TO INTERNAL SYMMETRIES. Rittenberg, V.; Marinescu, N.; Banyai, L. (Inst. of Physics, Bucharest). Nuovo Cim. (10), 51A: 899-912(Oct. 21, 1967).

In a crossing-symmetric model for the amplitudes, the scattering of degenerate pseudoscalar multiplets is considered in order to derive internal symmetries. For SU_2, SU_3, and G_2 the results are the same as by the N/D method. It is shown that these results do not require the assumption of the equality of the resonance masses. Unique solutions are obtained for SU_2 and SU_3 symmetries if the one-channel problem of the ρ resonance has a unique solution. Furthermore it is proved that the usual assumption of SU_2 symmetry when deriving SU_3 symmetry in the octet-octet scattering is not a necessary one. (auth)

3498 CROSSING-SYMMETRIC BOOTSTRAP MODEL OF A NEARLY DEGENERATE VECTOR-MESON OCTET. Banyai, L.; Marinescu, N.; Rittenberg, V. (Inst. of Physics, Bucharest). Nuovo Cim. (10), 51A: 913-31(Oct. 21, 1967).

The effect of pseudoscalar meson octet mass splitting and of "driving terms" on the vector-meson octet masses and coupling constants is investigated in a perturbation pattern of the SU_3-symmetric problem. Using a crossing symmetric model for bootstrap, results were obtained which are independent of the concrete form of the SU_3-symmetric unperturbated solution. (auth)

3499 TESTS OF SYMMETRY INVARIANCE IN STRONG-INTERACTION PHYSICS BY USING THE ELASTIC SCATTERING PROCESS $\bar{p}p \to \bar{p}p$. Gien, Tran Trong. (Faculte des Sciences, Bordeaux. Univ. of Newfoundland, St. John's Can.). Phys. Rev., 162: 1368-78(Oct. 25, 1967).

Various types of symmetry-invariance tests through the elastic scattering process $\bar{p}p \to \bar{p}p$ are proposed. The tests of charge-conjugation invariance are discussed in particular. Polarized proton targets made some of the experiments proposed for these tests easier. By these experiments, time-reversal invariance and charge-conjugation invariance can be tested independently. One can therefore make a direct test for CPT invariance. (auth)

3500 BROKEN SYMMETRY SUM RULES AND THE ALGEBRA OF CURRENTS. II. Copley, L. A.; Masson, D. (Univ. of Toronto). Phys. Rev., 162: 1410-15(Oct. 25, 1967).

An analysis of current-algebra methods of deriving broken SU(3) sum rules for three-point coupling constants initiated in a previous paper is expanded and concluded. It is shown quite definitely that current algebra does not intrinsically provide more information than is present in conventional group-theoretical derivations. In so doing, broken SU(3) sum rules are rederived for both strong- and weak-interaction coupling constants. In addition consistency conditions in the form of first order, broken SU(3) sum rules for partially conserved axial-vector current and partially conserved tensor current proportionality constants are found. (auth)

3501 MESON SYMMETRIES BASED ON NONCHIRAL SU(3) x SU(3). Bose, S. K. (Univ. of Notre Dame, Ind.).; Sudarshan, E. C. G. Contract AT(11-1)-427. Phys. Rev., 162: 1396-1403 (Oct. 25, 1967). (COO-427-67).

A scheme for meson symmetries based on the SU(3) ⊗ SU(3) group is presented. First, the phenomenological nonet model of Okubo is reinterpreted in terms of the representation (3,3*) of SU(3) ⊗ SU(3). More general representations of the form (d,d*), with d a triangular representation of SU(3), are next considered. It is noted that the assumption of the symmetry violation being generated by a hyperchargelike operator always leads to an equal-spacing rule for the meson masses, and to a degeneracy of several meson components. The origin of this degeneracy is discussed in some detail. The representation (6,6*) is treated at length. The possibility of realizing meson 36-plet (6,6*) is discussed with reference to existing experimental information. (auth)

3502 TWO PROBLEMS INVOLVING THE APPLICATION OF SU(3) THEORY TO NUCLEAR AND ELEMENTARY PARTICLE PHYSICS. Borse, Garold Joseph. Charlottesville, Va., Univ. of Virginia, 1966. 157p.

Thesis.

A calculation is made to relate the SU(3) production amplitude for the reaction $K^+ + p \to K^+ + K^0 + \Omega^-$ to other reactions involving one meson, one baryon initial states and two meson one hyperon final states. The number of amplitudes involved in a single reaction is found to be too large to obtain any useful relations at present. However, by making a few assumptions several interesting relations between cross sections were obtained. The dynamics of the Ω^- are then discussed, and it is concluded that the Ω^- may be viewed as a bound state of the $\Xi\bar{K}$ system. This result is reached by adapting the Chew-Low theory of π-N scattering to describe $\Xi\bar{K}$ scattering and using SU(3) to relate the $\Xi\bar{K}$ phase shifts to observed quantities. These phase shifts are then continued into the negative energy region and the mass of the bound state is obtained by using the effective range formula. The mass of the bound state obtained in this manner is very close to the observed mass of the Ω^-. The D/F coupling ratio is also calculated and is found to be close to the presently accepted value. The simplified SU(3) classification scheme due to Elliott is used to describe the odd parity, five-particle/one-hole states of ^{20}Ne. The wave functions are obtained by operating on a single intrinsic SU(3) function by a Wheeler projection integral. The energy levels calculated by diagonalizing a two by two matrix are found to resemble rotational bands with K = 0, and 2, and the energy splittings are quite close to experimental results. The K = 0 band, which is predicted to start at about 10 MeV, is not predicted by the rotational-vibrational model and is as yet unobserved. The calculated E2 transitions from this band to the K = 0 band are found to be quite large and may provide a method for locating this band. (Disser. Abstr.)

3503 BARYON MASS SPECTRA IN A DYNAMICAL S-WAVE SU(6) MODEL. Koerner, Juergen Hans Garlef. Evanston, Ill., Northwestern Univ., 1966. 83p.

Thesis.

Some results on the mass spectra of the $56^{(+)}$ and the proposed $70^{(-)}$ and $20^{(+)}$ SU(6) baryon multiplets are presented as calculated from a simple S-wave SU(6) invariant dynamical model involving first order mass deviations. The meson masses are taken from experiment and reasonable agreement is obtained with the experimentally known baryon masses. The masses of the missing members of the multiplets are estimated. The mass spectrum of the 70 is discussed in detail. A two parameter calculation using the experimental 56 and 35 mass spectra yields a mass spectrum in qualitative agreement with a recent nondynamical calculation of Gyuk and Tuan, in which 6 parameters were used. The three mixing angles occurring in the 70 are estimated from the model and found to be small. On this basis some new approximate mass rules are given. Explicit representations are derived for the reduced matrix elements of the strong interaction mass operator for the SU(6) 35, 56, 70, and 20 representations. (Disser. Abstr.)

Field Theories

Quantum Field Theory

Refer also to abstracts 3291, 3301, 3314, 3363, 3373, 3376, and 3480.

3504 DYNAMICS OF UNRENORMALIZABLE INTERACTIONS IN MINKOWSKI AND EUCLIDEAN SPACES. Guettinger, W. (CERN, Geneva); Pfaffelhuber, E. Nuovo Cim. (10), 52A: 389-431(Nov. 21, 1967).

A new approach to unrenormalizable and marginally singular field theories is developed using generalized-function techniques and an unsubtracted Lehmann representation for increasing spectral functions. Solution methods for a class of unrenormalizable equations of time-ordered and nontime-ordered functions are devised in Minkowski and Euclidean spaces. It is shown that within ladder and string approximations unrenormalizable theories possess perturbative solutions in Minkowski space which are finite in every order and do not suffer from an infinite set of subtraction constants, the axioms of relativistic field theory being satisfied. Renormalization factors Z_3^{-1} turn out to be differential operators (depending on a scaling parameter to a change of which observable quantities are insensitive) and may be set equal to one without the theory becoming a free one. By complex extension, solutions nonanalytic in the coupling constant can be generated, representing interactions not associable with particle exchange. A mathematical formulation of peratization is given and confronted with the Minkowski-space perturbation approach. The formalism is applied to propagators, Wightman functions and Bethe–Salpeter amplitudes of relativistic four-fermion theories in string and ladder approximations and it is shown that the locality and positive-definiteness axioms are satisfied. (auth)

3505 THE SECOND NOETHER THEOREM FOR LOCAL FIELD THEORIES. Oliveira, Colber G. (Centro Brasileiro de Pesquisas Fisicas, Rio de Janeiro); Vidal, Alberto. Notas Fis., Cent. Brasil. Pesqui. Fis., 13: 11-46(1967).

The invariance properties of localized fields under transformation groups involving arbitrary functions are studied from the point of view of the Action Principle. Such invariance implies in the existence of a set of identities at each space-time point, where the field is defined. These identities can be used as selection rules for the determination of the Lagrangian density of the field. It shows that the invariant Lagrangian density for coupled-field is defined in a local affine connected space (the space where the interaction takes place), with a greater number of dimensions than the usual Minkowski space. The relations which can be obtained between an infinitesimal gauge group and other infinitesimal discrete groups of invariance, such as the Lorentz group are also studied. This is done for the case of electrodynamics. (auth)

3506 ANALYSIS OF PRESENT EVIDENCE ON THE VALIDITY OF QUANTUM ELECTRODYNAMICS. Gatto, R. (Univ., Florence). pp 1-70 of High Energy Physics. Vol. II. Burhop, E. H. S. (ed.). New York and London, Academic Press, 1967.

A review is given on the experimental and theoretical work done in the last years relevant to the problem of the validity of quantum electrodynamics. Of particular concern is the question of a possible breakdown of the theory at small distances. The following topics are discussed: Lamb shift measurements and their implications; hyperfine structure of atomic hydrogen; hyperfine splitting in muonium and determinations of the fine structure constant; the anomalous magnetic moment of the electron; the muon magnetic moment, electron and muon scattering by electrons and nucleons; wide-angle electron pair production and bremsstrahlung; photoproduction of muon pairs, test of quantum electrodynamics with electron-electron and electron-positron colliding beams; and possible new couplings. (221 references). (auth)

3507 COMPLEX-PROPAGATOR INSERTIONS IN THE SQUARE DIAGRAM. Sarachik, E. S. (Stanford Univ., Calif.). Nuovo Cim. (10), 51A: 949-69(Oct. 21, 1967).

The problem of inserting a complex propagator in the crossed channel of the square diagram is considered. The propagator is spectrally represented and the square diagram with full propagator insertion is expressed as a spectral integral of square diagrams over an internal mass variable. The analytic properties of such diagrams in two complex variables, one internal mass and one external energy, are investigated in detail. These properties are then used to find the analytic properties of the full diagram with propagator insertions. (auth)

3508 PRINCIPLES AND LATEST RESULTS OF THE QUANTUM FIELD THEORY. IV. APPLICATIONS. Pocsik, Gyorgy (Lorant Eotvos Univ., Hungary). Magy. Fiz. Foly., 15: 377-95(1967). (In Hungarian).

Some of the fundamental applications of the quantum field theory were reviewed on the basis of the Wightman formulation, considering primarily the analytic properties. The decomposition of a beam was studied, making use of the Wightman axioms; it was thereby assumed that the existence of a single vacuum presupposes the property of the beam decomposition as a result of the reconstruction of the field. The correlation between the field, the Bose–Einstein and Fermi–Dirac statistics was reviewed, using field theory concepts; Pauli's study was used as the starting point. It was shown that a field possessing cyclic vacuum and satisfying the Wightman axioms represents a generalized free field only if all of its derived Wightman functions disappear, except the 2-point function. (Review article, 30 references). (TTT)

3509 CONSEQUENCES OF AN UNREASONABLE MASS SPECTRUM ON A RELATIVISTIC FIELD THEORY. Korff, D.; Fried, Z. (Lowell Technological Inst., Mass.). Nuovo Cim. (10), 52A: 173-91(Nov. 1, 1967).

The effects of an unreasonable mass spectrum on a relativistically invariant field theory are examined. It is found that a field operator which transforms according to a representation of the homogeneous Lorentz group cannot be given an unreasonable-mass-spectrum particle interpretation without violating Lorentz invariance. Conversely, it is found that the existence of an unreasonable mass spectrum for a field operator precludes it from transforming according to a representation of the homogeneous Lorentz group. However, a relativistically invariant theory is still possible. That is, a field theory may be constructed which maintains its form under a general Lorentz transformation. For the case of a discrete contribution to the unreasonable mass spectrum, the standard field-theoretical formulation is obtained as the square of the mass is allowed to approach zero from below. (auth)

3510 CALCULATION OF TRACES IN CONNECTION WITH DISPERSION RELATIONS IN ELECTRODYNAMICS. Thornblad, H. (Royal Inst. of Tech., Stockholm). Nuovo Cim. (10), 52A: 161-72(Nov. 1, 1967).

It is shown that a special introduction of five-vectors to take care of mass terms appearing in traces associated with Feynman diagrams, leads to a considerable simplification of the trace calculation. This technique is particularly efficient in connection with double dispersion relations in electrodynamics, as is demonstrated in an example. (auth)

3511 PERTURBATION THEORY AT HIGH ENERGY. Brown, L. M. (Univ., Rome); Kang, Ik-Ju. Nuovo Cim. (10), 52A: 210-23(Nov. 1, 1967).

Methods are presented for simplifying the algebraic structure of quantum electrodynamics perturbation amplitudes in the framework of the two-component fermion theory. A rule is presented for the general elimination of "double corner" diagrams. A second rule, valid only in the high-energy limit, gives a simple prescription for obtaining the amplitude which dominates in this limit, this being the amplitude which conserved "cohelicity," defined as helicity multiplied by fermion number. (auth)

3512 CONSERVED CURRENTS, RENORMALIZATION, AND ZERO-MASS STATES. Swieca, J. A. (Univ. of Sao Paulo, Brazil). Nuovo Cim. (10), 52A: 242-54(Nov. 1, 1967).

It is shown that charge renormalization corresponds to a form of a spontaneous symmetry breakdown: although the charge operator exists, it can no longer be written as a space integral of the charge density. This can only happen due to the presence of zero-mass states in the theory, in full agreement with recent results on continuous symmetry groups in relativistic field theories. (auth)

3513 METHOD FOR THE COMPUTATION OF HIGHER-ORDER RADIATIVE CORRECTIONS; APPLICATION TO THE $g\varphi^3$ MODEL. II. COMPUTATIONAL TECHNIQUES. Calmet, J. (Faculte des Sciences, Marseille); Soffer, J.; Seneor, R.; Visconti, A. Phys. Rev., 162: 1390-3(Oct. 25, 1967).

As an application of the method which has been given in Paper I, all the radiative corrections for the $g\varphi^3$ model are computed up to the sixth order. These calculations are performed as a test for the method which will be used in the realistic case of quantum electrodynamics. (auth)

3514 METHOD FOR THE COMPUTATION OF HIGHER-ORDER RADIATIVE CORRECTIONS; APPLICATION TO THE $g\varphi^3$ MODEL. I. METHOD. Soffer, J. C.; Visconti, A. (Faculte des Sciences, Marseille). Phys. Rev., 162: 1386-9(Oct. 25, 1967).

In the framework of a self-interacting scalar field with a cubic interaction, all radiative corrections up to the sixth order were computed. In Paper I, the functional method which gives the

renormalized corrections is described while Paper II will be devoted to the computation of these radiative corrections. These calculations are performed as a test for the method which will be used in the realistic case of quantum electrodynamics. (auth)

3515 NORMALIZATION OF BETHE-SALPETER AMPLITUDES. Nishijima, K.; Singh, A. H. (Univ. of Illinois, Urbana). Phys. Rev., 162: 1740-6(Oct. 25, 1967).

Many different methods for normalizing Bethe–Salpeter amplitudes for bound states have been known. Derivations of the normalization condition based on conservation of charge and of energy-momentum are studied in detail, and it is shown that the final result in both cases is identical with the one derived from other methods. (auth)

3516 OPERATOR FORMALISM FOR DAUGHTER TRAJECTORIES IN THE BETHE-SALPETER EQUATION. Chung, Victor; Wright, Jon (Univ. of California, San Diego). Contract AT-11-1-gen-10. Phys. Rev., 162: 1716-22(Oct. 25, 1967). (UCSD-10P10-26).

The existence of daughter Regge poles is demonstrated by a raising and lowering operator formalism without explicit use of O(4) symmetry. The commutation relations of these operators with the kernel of the Bethe–Salpeter integral equation require the existence of the degeneracy which leads to an infinite chain of daughter Regge trajectories. It is found that the chain of daughter Regge poles does not terminate even if the parent pole is at a positive integer. A formula is given for calculating the slopes of the Regge trajectories. (auth)

3517 REGGE DAUGHTER TRAJECTORIES IN THE BETHE-SALPETER EQUATION. Chung, Victor; Snider, D. R. (Univ. of California, San Diego). Contract AT(11-1)-gen-10. Phys. Rev., 162: 1639-43(Oct. 25, 1967). (UCSD-10P10-24).

Parent and daughter Regge trajectories are found numerically in the scalar Bethe–Salpeter equation with trilinear coupling in the ladder approximation. By using the ordinary partial-wave projection of the scattering amplitude, the trajectories over a range of energy below threshold are obtained; and by projecting the scattering amplitude into 4-dimensional spherical harmonics, the slope and intercept of the trajectories at $s = 0$ are found. (auth)

3518 GAUGE PROBLEM IN QUANTUM FIELD THEORY. Strocchi, F. (Princeton Univ., N. J.). Phys. Rev., 162: 1429-38(Oct. 25, 1967).

The difficulties connected with the quantization of the electromagnetic field are analyzed in the framework of axiomatic field theory. Under the assumptions: (1) existence of the vacuum, invariant under the Poincaré group, (2) existence of a representation of the Poincaré group such that the fields have tensor transformation properties, and (3) analyticity of the two-point function in the forward tube, it is proved that the Maxwell equations $\partial^\mu F_{\mu\nu} = 0$, $\epsilon^{\lambda\mu\nu\rho}\partial_\mu F_{\nu\rho} = 0$ do not admit the classical solution $F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$, where the potential transforms as a four-vector. The result is very general and can be obtained without assuming either local commutativity or the spectral condition; it is also independent of whether the metric is positive or not. Thus the difficulties connected with the gauge problem have very little to do with the Lorentz condition, indefinite metric, etc., but rather they arise at the very beginning with the introduction of the four-vector potential. As a corollary of the above result, the representations of the Poincaré group for massless spin-one particles in quantum field theory are shown to be essentially different from the corresponding ones of the classical case. The Fock representation in the Gupta–Bleuler approach is discussed in connection with the Lehmann–Symanzik–Zimmermann formulation of quantum electrodynamics. Some care must be used in the definition of the asymptotic Hilbert space since, by the previous result, unphysical photon states must be introduced as asymptotic states in order to have a local theory. The requirement that these states should not affect any physical result imposes definite restrictions on the S matrix. These conditions guarantee that the definition of physical photon states in terms of equivalence classes still has significance in the presence of interactions. (auth)

3519 REMARKS ON THE APPLICATION OF THE JOST-LEHMANN-DYSON REPRESENTATION TO EQUAL-TIME COMMUTATORS. Schroer, B. (Univ. of Pittsburgh); Stichel, P. Contract AT(30-1)-3829. Phys. Rev., 162: 1394-6(Oct. 25, 1967). (NYO-3829-5).

It is shown that Jost–Lehmann–Dyson spectral functions for matrix elements of scalar field commutators can lead to the existence of (finite) equal-time commutators with an arbitrary number of gradient terms. The conventional mechanism for the appearance of gradient terms is via the covariant tensor operators acting on the scalar commutator functions. These terms we call of "kinematical origin," whereas the first-mentioned purely scalar mechanism is called "nonkinematical." This latter possibility seems to have been overlooked in the recent literature. (auth)

3520 SOME REMARKS ON THE GENERAL THEORY OF QUANTIZED FIELDS. Nagel, B. (Royal Inst. of Tech., Stockholm). pp 3-21 of Proceedings of the Liperi Summer School in Theoretical Physics, August 1–6, 1966. A. Elementary Particle Physics. Helsinki, University of Helsinki, 1967.

See CONF-660834-(Pt.A).

The fundamental assumptions of axiomatic field theory are briefly reviewed. Then the topological properties of the theory, which through a direct application of known mathematical results make it possible to show the existence and nature of a complete set of generalized energy–momentum eigenfunctions, i.e., generalized states with sharp values of energy and momentum, are considered. (J.F.P.)

3521 THE STUDY OF THE BETHE–SALPETER EQUATION IN SCALAR FIELD THEORIES AND HIGH ENERGY SCATTERING. Nitzan, Shmuel Nussinov. Seattle, Univ. of Washington, 1966. 206p.

Thesis.

The Bethe-Salpeter equation and another analogous equation derived below are used for finding the asymptotic behavior of various infinite sets of graphs which arise in $\lambda\phi^4$ theory. The cases of weak and strong coupling limits are discussed in detail. The Mellin transform method of M. Banerjee, M. Kugler, C. A. Levinson and I. J. Muzinich and four dimensional spherical harmonics method of Bjorken and others are used. The partial wave equation for the forward scattering amplitude is rederived by considering the absorptive part equation, and without resorting to wick rotations. Possible extensions of B.K.L.M. results to nonzero masses and nonforward scattering are discussed in some detail. The divergence of the perturbation expansion for the $\lambda\phi^4$ kernel of the Bethe–Salpeter equation, and an interesting inequality for the contribution to absorptive parts are also derived. (Disser. Abstr.)

3522 ANALYTIC PROPERTIES OF PERTURBATION THEORY DIAGRAMS CONTAINING COMPOSITE PARTICLES IN A MODEL FIELD THEORY. Sarachik, Edward Stuart. Waltham, Mass., Brandeis Univ., 1966. 134p.

Thesis.

The Lagrangian Zachariasen model is fully investigated: the Feynman rules are developed, the diagrams summed, and the various quantities renormalized. It is shown that the renormalized quantities satisfy the expected dispersion relations. A simplified propagator is constructed in this model and inserted into the single loop self-energy graph and into the crossed channel of the single loop vertex and scattering graphs. The analytic properties of diagrams as a function of one external and one internal variable are studied in each case. These properties are then used to find the singularities of the graphs with propagator insertions. (Disser. Abstr.)

Gravitation and General Relativity

Refer also to abstracts 3259 and 3385.

3523 (JINR-P2-3485) OB ODNOM VNESHNEM RESHENII DLYA STATICHESKIKH ELEKTRICHESKOGO I MAGNITNOGO DIPOLEI V TEORII TYAGOTENIYA. (Singular Extrinsic Solution for the Static Electric and Magnetic Dipoles in the Theory of Gravitation). Asanov, R. A. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1967. 7p. (In Russian). Dep.

Fisher and Tauber present exact static solutions of the Einstein and Maxwell equation for electric and magnetic dipoles. These solutions have the form: $\exp(\alpha) = \exp(\beta) = \exp(-\gamma) \approx 1 - p\sqrt{\kappa}\cos\theta/r^2$. Here κ is the Newtonian gravitational constant; p is the moment of the corresponding dipole ($p > 0$); and $r^2 = \rho^2 + z^2$. This solution results in an unsatisfactory form of the gravitational potential V due to the omission of "neglected Schwarzshild terms." The Einstein and Maxwell equations are rewritten, and a series solution is sought in terms of $\kappa m/r$ and $[p(\kappa)^{0.5}]^{0.5}/r$, which are assumed to be small. With $p = 0$ these series convert to series obtained by the Schwarzshild solution. The electric and magnetic dipole described by the extrinsic solution shows the "usual" properties. Its total mass is equal to m, and the gravitational field at large distances is Newtonian in character due to the presence of a Schwarzshild term $\kappa m/r$ in the solution. (TTT)

3524 GENERAL RELATIVITY THEORY AND MINKOWSKI COMPARISON METRICS. Westpfahl, Konradin. Fortschr. Phys., 15: 309-31(1967). (In German).

The theory of the doubled mass determination including the construction of the gravitational field canonical energy–momentum

tensor and the gravitational field energy-momentum tensor symmetrized by means of the spin density was systematically outlined. The Lorentz invariant theory of weak gravitational fields was developed in the first and second approximations. The Lagrange density of the Einstein field equation served as the initial point in this development. (tr-auth)

3525 SO-CALLED PARADOXES OF THE THEORY OF RELATIVITY. Janossy, L. (Hungarian Academy of Sciences, Budapest). At. Energy Rev., 5: No. 2, 159-71(1967).

The question of a possible re-interpretation of the formalism of the theory of relativity is briefly considered, and the alleged paradoxes of this theory are discussed. An analysis of the role of ideal experiments in the structure of scientific thought is considered. (J.F.P.)

3526 STRUCTURE OF THE GRAVITATIONAL LAGRANGIAN. Polievktov-Nikoladze, N. M. (Tbilisi State Univ.). JETP Lett. (USSR) (Engl. Transl.), 6: 54-6(July 15, 1967).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu, 6: 531-3(July 15, 1967).

In order to further investigate the δ effect in the Einstein equations, the quantity of X in the Lagrangian $\Lambda = (R + X)/2x_1$ is studied, where $x_1 > 0$, R is the scalar curvature of four-space, and X is an invariant that depends only on the metric tensor and its derivatives and vanishes more rapidly than R when $R^{ik}_{lm} \to 0$ (R^{ik}_{lm} is a Riemann tensor which is antisymmetric in the upper and lower indices. Several properties of X are established. (J.F.P.)

3527 GRAVITY WAVES DETECTED FOR THE FIRST TIME? Weber, Joseph (Univ. of Maryland, College Park). Sci. Res., 2: No. 10, 41-3(Oct. 1967).

An experimental investigation of gravity waves is described. The detectors used are designed to record oscillations in the curvature of space with frequencies in the vicinity of 1660 cps. The prototype detector is essentially a large aluminum cylinder two feet in diameter, five feet long and weighing a ton and a half. Quartz strain gages convert the mechanical oscillations to voltages which are amplified by low-noise amplifers. Extreme precautions are used to isolate the cylinder from environmental noise. The events observed are occasional output pulses at least five times as high as the mean noise deviation. There have been eight such events observed since the first of the year. However, another year or two are required to confirm these events as gravity waves rather than earth signals. Another independent effort to detect gravity-wave coincidences is also briefly described. The detectors for this experiment are the earth and the moon. Incident gravity waves should excite natural modes of vibration in these bodies just as in an aluminum cylinder. The instrumentation consists of extremely sensitive gravimeters that measure slight changes in the value of g at the earth or moon surfaces during the passage of gravity waves. (J.F.P.)

3528 PHYSICAL CONSEQUENCES OF FOCK'S CONFORMAL HYPOTHESIS. Noerdlinger, Peter D. (Univ. of Iowa, Iowa City). Phys. Rev., 162: 1288-91(Oct. 25, 1967).

It is shown that, when taken literally, Fock's method of reinterpreting the spatial metric in Einstein's general theory of relativity leads to the result that clocks do not measure proper time, and consequently to disagreement with gravitational redshift experiments. (auth)

3529 TESTING GENERAL RELATIVITY WITH LASER RANGING TO THE MOON. Baierlein, Ralph (Wesleyan Univ., Middletown, Conn.). Phys. Rev., 162: 1275-88(Oct. 25, 1967).

An assessment is made of some possibilities inherent in precise laser ranging to the moon for testing Einstein's theory of gravitation. The anticipated accuracy of the determination of the light transit time for a laser pulse returned by an optical corner reflector on the lunar surface is about two parts in 10^{10}. Such high precision opens the possibility of detecting general relativistic effects in both the light propagation itself and in the lunar motion. The detailed analysis presented here indicates that, although the effects on light propagation are probably not detectable, there are general relativistic effects in the lunar motion which appear to be observationally accessible with the expected laser-ranging data. Observation of the dominant effect would provide a significant test of the correctness of the geodesic equation, to $O(1/c^2)$ beyond the Newtonian approximation, for describing the motion of bodies in a gravitational field. (auth)

3530 QUANTUM THEORY OF GRAVITY. II. THE MANIFESTLY COVARIANT THEORY. DeWitt, Bryce S. (Institute for Advanced Study, Princeton, N. J. Univ. of North Carolina, Chapel Hill). Phys. Rev., 162: 1195-1239(Oct. 25, 1967).

Contrary to the situation which holds for the canonical theory described in the first paper of this series, there exists at present no tractable pure operator language on which to base a manifestly covariant quantum theory of gravity. One must construct the theory by analogy with conventional S-matrix theory, using the c-number language of Feynman amplitudes when nothing else is available. The present paper undertakes this construction. It begins at an elementary level with a treatment of the propagation of small disturbances on a classical background. The classical background plays a fundamental role throughout, both as a technical instrument for probing the vacuum (i.e., analyzing virtual processes) and as an arbitrary fiducial point for the quantum fluctuations. The problem of the quantized light cone is discussed in a preliminary way, and the formal structure of the invariance group is displayed. A condensed notation is adopted which permits the Yang-Mills field to be studied simultaneously with the gravitational field. Generally covariant Green's functions are introduced through the imposition of covariant supplementary conditions on small disturbances. The transition from the classical to the quantum theory is made via the Poisson bracket of Peierls. Commutation relations for the asymptotic fields are obtained and used to define the incoming and outgoing states. Because of the non-Abelian character of the coordinate transformation group, the separation of propagated disturbances into physical and nonphysical components requires much greater care than in electrodynamics. With the aid of a canonical form for the commutator function, two distinct Feynman propagators relative to an arbitrary background are defined. One of these is manifestly covariant, but propagates nonphysical as well as physical quanta; the other propagates physical quanta only, but lacks manifest covariance. The latter is used to define external-line wave functions and non-radiatively corrected amplitudes for scattering, pair production, and pair annihilation by the background field. The group invariance of these amplitudes is proved. A fully covariant generalization of the complete S matrix is next proposed, and Feynman's tree theorem on the group invariance of non-radiatively corrected n-particle amplitudes is derived. The big problem of radiative corrections is then confronted. The resolution of this problem is carried out in steps. The single-loop contribution to the vacuum-to-vacuum amplitude is first computed with the aid of the formal theory of continuous determinants. This contribution is then functionally differentiated to obtain the lowest-order radiative corrections to the n-quantum amplitudes. These amplitudes split automatically into Feynman baskets, i.e., sums over tree amplitudes (bare scattering amplitudes) in which all external lines are on the mass shell. This guarantees their group invariance. The invariance can be made partially manifest by converting from the noncovariant Feynman propagator to the covariant one, and this leads to the formal appearance of fictitious quanta which compensate the nonphysical modes carried by the covariant propagator. Although avoidable in principle, these quanta necessarily appear whenever manifestly covariant expressions are employed, e.g., in renormalization theory. The fictitious quanta, however, appear only in closed loops and are coupled to real quanta through vertices which vanish when the invariance group is Abelian. The vertices are nonsymmetric and always occur with a uniform orientation around any fictitious quantum loop. The problem of splitting radiative corrections into Feynman baskets becomes more difficult in higher orders, when overlapping loops occur. This problem is approached with the aid of the Feynman functional integral. It is shown that the "measure" or "volume element" for the functional integration plays a fundamental role in the decomposition into Feynman baskets and in guaranteeing the invariance of radiative corrections under arbitrary changes in the choice of basic field variables. The "measure" has two effects. Firstly, it removes from all closed loops the noncausal chains of cyclically connected advanced (or retarded) Green's functions, thereby breaking them open and ensuring that at least one segment of every loop is on the mass shell. Secondly it adds certain nonlocal corrections to the operator field equations, which vanish in the classical limit $\hbar \to 0$. The question arises why these removals and corrections are always neglected in conventional field theory without apparent harm. It is argued that the usual procedures of renormalization theory automatically take care of them. In practice the criteria of locality and unitarity are replaced by analyticity statements and Cutkosky rules. It is virtually certain that the "measure" may be similarly ignored (set equal to unity) in gravity theory, and that attention may therefore be confined to primary diagrams, i.e., diagrams which contain Feynman propagators only, with no noncausal chains removed. A general algorithm is given for obtaining the primary diagrams of arbitrarily high order, including all fictitious quantum loops, and the group invariance of the amplitudes thereby defined is proved. Essential to all these derivations is the use of a background field satisfying the classical "free" field equations. It is never necessary to employ external sources, and hence the well-known difficulties arising with sources in a non-Abelian context are avoided. (auth)

3531 QUANTUM THEORY OF GRAVITY. III. APPLICATIONS OF THE COVARIANT THEORY. DeWitt, Bryce S. (Institute for Advanced Study, Princeton, N. J. Univ. of North Carolina, Chapel Hill). Phys. Rev., 162: 1239-56(Oct. 25, 1967).

The basic momentum-space propagators and vertices (including those for the fictitious quanta) are given for both the Yang-Mills and gravitational fields. These propagators are used to obtain the cross sections for gravitational scattering of two scalar particles, scattering of gravitons by scalar particles, graviton-graviton scattering, two-graviton annihilation of scalar-particle pairs, and graviton bremsstrahlung. Special features of these cross sections are noted. Problems arising in renormalization theory and the role of the Planck length are discussed. The gravitational Ward identity is derived, and the structure of the radiatively corrected 1-graviton vertex for a scalar particle is displayed. The Ward identity is only one of an infinity of identities relating the many-graviton vertex functions of the theory. The need for such identities may be eliminated in principle by computing radiative corrections directly in coordinate space, using the theory of manifestly covariant Green's functions. As an example of such a calculation, the contribution of conformal metric fluctuations to the vacuum-to-vacuum amplitude is summed to all order. The physical significance of the renormalization terms is discussed. Finally, Weinberg's treatment of the infrared problem is examined. It is not difficult to show that the fictitious quanta contribute negligibly to infrared amplitudes, and hence that Weinberg's use of the DeDonder gauge is justified. His proof that the infrared problem is gravidynamics can be handled just as in electrodynamics is thereby made rigorous. (auth)

3532 INTERACTION OF WAVE EQUATIONS WITH A CURVED METRIC. Feinblum, David Alan. Troy, N. Y.; Rensselaer Polytechnic Inst., 1966. 90p.

Thesis.

In order to investigate whether very small structures of the geon type could represent fundamental particles, an attempt was made to consider structures consisting of small numbers of particles interacting in a self-consistent manner with the gravitational field produced by the particle energy momentum tensor. Restriction was made to spherically symmetric geometries. For a particle satisfying the Dirac equation this could not be done; however, a structure of two particles could satisfy the geometric requirement. A single particle satisfying the Klein–Gordon equation could also satisfy the requirement. For the latter case, the equations of the self-consistent field were solved for several cases of bound states. A discrepancy was found between the meaning of the term "energy" in quantum mechanics and general relativity. A revision of the model eliminated this difficulty, made possible an energy minimum principle, and suggested a method of treating interaction structures. The inference is drawn that geometric structures of this type may have a use as a model for fundamental particles after a second quantization treatment of the model becomes possible. (Disser. Abstr.)

Scattering Theory

Refer also to abstracts 3391 and 3521.

3533 DISPERSIVE SUM RULES AND LOW-ENERGY LIMITS. Del Giudice, E.; Galzenati, E. (Univ., Napoli, Italy. Istituto Nazionale di Fisica Nucleare, Napoli, Italy). Nuovo Cim. (10), 52A: 606-16(Nov. 21, 1967).

A new family of sum rules is derived from current algebra, both by a dispersive approach and by a "frame of reference" method. The sum rules involve integrals on the masses associated with the currents. They allow one to evaluate corrections to the relations obtained by means of the usual sum rules. In particular, [A,A] commutators are discussed. (auth)

3534 LONGITUDINAL DEPOLARIZATION OF A BEAM OF SPIN-1/2 PARTICLES. Braicovich, L. (Istituto di Fisica del Politecnico, Milan. CNR, Milan). Nuovo Cim. (10), 52A: 566-76(Nov. 21, 1967).

The average longitudinal depolarization suffered by a longitudinally polarized beam of spin-$\frac{1}{2}$ particles undergoing multiple scattering is calculated by means of a new formulation of the so-called iteration theory given by Passatore. This new formulation takes into account the probability distribution of the number of scatterings and the lateral deflections of the particles. The equivalence between the iteration theory and the depolarization theories based on the transport equation is established within very wide limits. All the results are limited to the case in which the depolarization due to the energy loss of the particles is negligible. (auth)

3535 CLOSING THE BACKGROUND INTEGRAL. Abbe, W. J. (Univ. of Michigan, Ann Arbor); Srivastava, Y. N. Nuovo Cim. (10), 52A: 551-65(Nov. 21, 1967).

The asymptotic behavior of the partial-wave S-matrix given previously is used, namely, that asymptotically in the left-half λ-plane the single two-body, elastic S-matrix element has the behavior exp $[2\pi i\lambda]$ in a sector of the left-half λ-plane for a fairly general class of (energy-dependent) potentials, and consequent representations for the total scattering amplitude are derived. Two basic representations are given. The first is valid when the potential is such as to imply the Mandelstam symmetry; the second is an extension of the earlier Khuri representation and is valid for a fairly general superposition of (energy-dependent) Yukawa potentials; the latter representation is given both with and without subtracting the Born term. A brief comparison with exact results shows good agreement in a one-pole approximation. (auth)

3536 ASYMPTOTIC BEHAVIOR OF THE S-MATRIX IN THE LEFT HALF λ-PLANE. Abbe, W. J. (Univ. of Michigan, Ann Arbor); Srivastava, Y. N. Nuovo Cim. (10), 52A: 537-50 (Nov. 21, 1967).

Within the framework of potential theory, it is shown that the partial wave S-matrix is bounded by exp $[2\pi i\lambda]$ asymptotically for Re $\lambda < 0$, for a fairly general class of energy-dependent superpositions of Yukawa potentials, and consequently recent representations of the scattering amplitude, which were proved for a more restricted class of potentials, are therefore true under these more general conditions. (auth)

3537 PADE APPROXIMANT, J-FRACTION AND K-MATRIX IN POTENTIAL SCATTERING. Chen, A. (St. John's Univ., Jamaica, N. Y.). Nuovo Cim. (10), 52A: 474-85(Nov. 21, 1967).

The theory of J-fractions is applied to obtain the continued fraction representation of Padé approximants for K-matrix in potential scattering. It is shown that when a potential can be approximated by a sum of separable potentials of the same sign on the energy shell, the J-fraction is positive definite. The necessary and sufficient condition for the convergence of a positive definite J-fraction to a meromorphic fraction is the vanishing of its coefficients as the rank increases. Convergence of the sequence of approximants for the scattering length of square-well potential is rigorously established in terms of the convergence properties of the positive definite J-fraction. (auth)

3538 SOME RECENT WORKS ON REGGE POLES AND THE THREE-BODY PROBLEM. Mandelstam, Stanley (Univ. of California, Berkeley). pp 1-21 of Elementary Particle Physics. Takeda, Gyo; Fujii, Akihiko (eds.). Tokyo, Syokabo Publishing Co. and New York, W. A. Benjamin, Inc., 1967.

Three lectures are presented on some recent works on Regge poles and the three-body problem. In the first three-body N/D equations are constructed, which are analogous to the familiar two-body N/D equations. It is assumed that all the singularities of a partial-wave amplitude, other than the right-hand unitarity cut, are known. The second lecture treats some features of Regge trajectories with three-particle and multi-particle intermediate states. A procedure is outlined for removing the difficulties involved in proving from the N/D equations that the amplitude is meromorphic in the J-plane. Information is obtained about the limit points of the Regge trajectories at large values of the energy. These properties are related to the hypothesis that the trajectories rise indefinitely with increasing energy. A few comments are also made of the behavior of the phase shift at infinite energy in a system where the trajectories rise indefinitely, and it is observed that this behavior is correlated with the decrease of form factors at high energy. The third lecture deals with the asymptotic behavior of scattering amplitudes for unequal mass particles in the backward direction as the energy becomes infinite. (L.B.S.)

3539 STATIONARY APPROACH TO THE DEFINITION OF TIME DELAY IN THE SCATTERING PROCESS. Vedrinski, R. V. (Univ., Rome). Nuovo Cim. (10), 51B: 487-91(Oct. 11, 1967).

A new stationary approach to the problem of the time of scattering is proposed. The correspondence between this approach and the usual one is established. (auth)

3540 REGGE TRAJECTORIES FOR EVEN-POWER POTENTIALS. Aly, H. H.; Mueller, H. J. W.; Schilcher, K. (American Univ. of Beirut). Nucl. Phys., B3: 401-6(1967).

Regge trajectories for generalized even-power potentials are investigated using previous results for Yukawa potentials. Particular examples treated are the harmonic oscillator and Gaussian potentials. (auth)

3541 NON-REGGE TERMS IN SINGLE CURRENT AMPLITUDES. Polkinghorne, J. C. (International Atomic Energy Agency, Trieste, Italy). Nucl. Phys., B3: 395-400(1967). IC-67/67).

It is shown from a perturbation theory model that in general non-Regge terms are to be found in amplitudes involving a single current. Complete Reggeization can only be expected in unitary amplitudes. The relation of this fact to the recent suggestion of extra terms in sum rules is discussed. (auth)

3542 THE CAYLEY EQUATIONS OF A REDUCIBLE FEYNMAN DIAGRAM. Barucchi, G. (Univ., Turin). Nuovo Cim. (10), 52A: 146-60(Nov. 1, 1967).

The leading Landau curve of a once-reduced sixth-order ladder diagram is studied by using the formalism of the Cayley determinants. From the Landau equations Cayley equations are derived which represent a reducible algebraic curve in the (s,t)-plane. The properties of said curve are derived. The Cayley equations are proved to be equivalent to the Landau ones even if the former represent a reducible curve. (auth)

3543 CHARGE INVARIANCE AND GROUP-TRANSFORMATION PROPERTIES OF THE SCATTERING IN A DYNAMICAL MODEL. Giovannini, A.; Predazzi, E. (Univ., Turin. Istituto Nazionale di Fisica Nucleare, Turin). Nuovo Cim. (10), 52A: 255-73(Nov. 1, 1967).

A simple dynamical scheme is used in which as the result of the high-energy collision of two heavy particles an a priori arbitrary number of soft scalar particles can be produced. It is shown that the imposition of charge invariance is sufficient to derive the transformation properties of the transition operator with respect to the variables charge and number of soft particles emitted. As a consequence a mapping is established between a certain matrix element of the transition operator and the elements of $SU_{1,1}$. In establishing this mapping an undetermined function $\gamma(k, \theta)$ is introduced. The predictions of the model on the law of multiple production are discussed and it is shown how the above mentioned arbitrary function characterizing the mapping can be phenomenologically determined from a comparison with experiment. (auth)

3544 N/D SOLUTION OF THE n-POLE PROBLEM. Martin, Arthur W. (Stanford Univ., Calif.). Phys. Rev., 162: 1529-34 (Oct. 25, 1967).

The explicit solution of the n-pole problem in relativistic partial-wave dispersion relations in shown to be a simple generalization of the potential-scattering results of Nyman. The solution and its application to self-consistent S-matrix calculations is discussed. (auth)

3545 UNITARITY AND THE MANDELSTAM REPRESENTATION. I. MOMENT CONDITIONS FOR THE DOUBLE SPECTRAL FUNCTIONS. Martin, Arthur W. (Stanford Univ., Calif.). Phys. Rev., 162: 1534-42(Oct. 25, 1967).

It was shown by Mandelstam that the double spectral function in the elastic strip is determined by double integrals over crossed-channel absorptive parts. The content of this consequence of elastic unitarity can be expressed in a number of different ways, some of which significantly simplify the problem of determining the spectral function for given absorptive parts. Among the results presented are rigorous moment conditions, "open-ended" integrals, and the Laplace transform of the double spectral function. An approximation procedure for the determination of the spectral function in terms of simple, one-dimensional integrals over the absorptive parts is developed. (auth)

3546 EXPANSION OF THE TWO-PARTICLE SCATTERING AMPLITUDE IN TERMS OF THE MATRIX ELEMENTS OF THE LORENTZ GROUP. Rubin, M. H. (Univ. of Wisconsin, Madison). Contract AT(11-1)-881. Phys. Rev., 162: 1551-5(Oct. 25, 1967). (COO-881-100).

Starting from a dispersion relation, the scattering amplitude for two spinless particles is expanded in terms of the matrix elements of the unitary representations of the Lorentz group. The expansion consists of two parts: a background term and a series of pole terms. It is shown that this expansion leads to Regge-like behavior at large momentum transfers, and that each pole term and the background term in this expansion have the correct analytic structure in the momentum-transfer plane. (auth)

3547 DISPERSION RELATIONS FOR THREE-PARTICLE SCATTERING AMPLITUDES. III. Rubin, M. H. (Univ. of Wisconsin, Madison); Sugar, R. L.; Tiktopoulos, George. Contract AT(11-1)-881. Phys. Rev., 162: 1555-69(Oct. 25, 1967).

A discussion of the scattering of three nonrelativistic, spinless particles interacting via two-body Yukawa potentials is continued. The on-energy-shell amplitudes for the breakup of a two-particle bound state, for elastic scattering off a bound state, and for rearrangement are studied as a function of the total center-of-mass energy E for fixed physical values of the angle variables. It is shown that each of these amplitudes is given by a "Fredholm series" which is uniformly convergent with respect to E for all values of E on the physical sheet including the real axis. It is also shown that each of these amplitudes satisfies a dispersion relation in E for fixed physical values of the angle variables. Except for simple poles which arise from the lowest-order diagrams, all of the singularities lie on the real E axis. (auth)

3548 RELATIVISTIC HARMONIC OSCILLATOR AND SUPERCONVERGENT AMPLITUDES. Cocho, G. (Univ. Mexico, Mexico City); Fronsdal, C.; Grodsky, I. T.; White, R. Phys. Rev., 162: 1662-71(Oct. 25, 1967).

Current commutation relations and Fubini sum rules are saturated in a model that is a relativistic version of the three-dimensional harmonic oscillator. The model is essentially determined by the requirement that a local nonderivative relativistic coupling of the oscillator to an external electromagnetic field give rise to form factors that reduce to the usual result in the nonrelativistic limit. The relativistic form factors decrease as a power of the invariant momentum transfer, although they fall off exponentially in the limit $c \to \infty$. Vertex functions and scattering amplitudes are investigated, and it is found that (i) the Compton scattering amplitudes for current-particle interactions satisfy Fubini sum rules. (ii) All strong-interaction amplitudes are superconvergent in the Born approximation, in which an infinite/equal-mass multiplet is either exchanged or forms a set of intermediary states. (iii) Scattering amplitudes can be arranged in a hierarchy of increasing convergence (e.g., no spin flip, single spin flip, double spin flip), as suggested by de Alfaro et al. Finally, the problem of introducing the mass spectrum in the one-particle propagator is discussed. (auth)

3549 SOME FEATURES OF ANGULAR-MOMENTUM BRANCH POINTS. Schwarz, John H. (Princeton Univ., N. J.). Phys. Rev., 162: 1671-6(Oct. 25, 1967).

Arguments for the existence of angular-momentum branch points based on the necessity for the Gribov–Pomeranchuk singularities are reviewed. Sum rules for scattering amplitudes on the second sheet are then deduced. Reasons are given for expecting two kinds of branch points to be present, namely, those described as "Regge pole plus Regge pole" and "Regge pole plus elementary particle" (called types 1 and 2, respectively). It is argued that the latter must be concealed by the former in the scattering region, and from the requirement that the branch points are suitably positioned in general, an inequality on derivatives of Regge-pole trajectories is derived. A model of the Amati–Fubini–Stanghellini type is examined to indicate why type-2 branch points may be expected to occur in a theory without elementary particles. (auth)

3550 POSSIBILITY OF THE UNIVERSALITY OF REGGE TRAJECTORY SLOPES. Hwa, Rudolph C. (State Univ. of New York, Stony Brook). Phys. Rev., 162: 1706-9(Oct. 25, 1967).

It is shown that all Regge trajectories share some universal properties in their slopes if it is required that scattering amplitudes have no essential singularities at nonsense, wrong-signature values of the angular momentum, and if some technical assumptions are valid. (auth)

3551 POWER BEHAVIOR OF THE SCATTERING AMPLITUDE AT FIXED MOMENTUM TRANSFER AND A RECONSIDERATION OF THE CERULUS-MARTIN LOWER BOUND. Chiu, Charles B.; Tan, Chung-I (Univ. of California, Berkeley). Contract W-7405-eng-48. Phys. Rev., 162: 1701-5(Oct. 25, 1967). (UCRL-17552).

It is shown that the assumption of maximal analyticity of first degree and fixed-t power behavior of the scattering amplitudes in general imply a lower bound at a fixed angle. The fixed-angle lower bound takes the form $\exp[-c_\gamma(z_s)\, s^\gamma \ln s]$, where $c_\gamma(z_s)$ and γ are positive. The precise value of γ depends on the specific assumptions on the fixed-t bound of the scattering amplitude. In particular, the assumptions made by Cerulus and Martin correspond to $\gamma = \frac{1}{2}$, and for the case of a linearly rising trajectory, $\gamma = 1$. Furthermore, a nonzero lower bound was obtained at $z_s = 0$, which heretofore was given as zero. (auth)

3552 BRANCH POINTS IN THE ANGULAR MOMENTUM PLANE. Rothe, Heinz Juergen. Berkeley, Calif., Univ. of California, 1966. 123p.

Thesis.

A study is made of the Amati, Fubini, Stanghellini (AFS) type of approximation to the amplitudes associated with the exchange of a single Regge pole and an elementary spinless particle, and of two Regge poles, respectively. The location, motion, and nature of the singularities in the complex angular momentum plane of the s reaction which appear in these approximations, and their cancella-

tion in the full diagram, are considered in detail; the singularities are found to be of two general types: branch points whose positions are independent of particle masses, and those which depend on them. Only the former ones determine the asymptotic behavior of the AFS amplitudes in the physical scattering region, while the latter singularities appear only on the physical sheet via the mass-independent branch points at unphysical momentum transfers. The same method used in the study of the AFS approximation to the diagrams which do not have the AFS-type singularities is applied to the analysis of the Mandelstam diagrams for which the above-mentioned cancellation of the cuts does not occur. The analysis, although less rigorous, suggests that the location and nature of the singularities in the j plane are the same as those found for the AFS type of approximations to their simpler versions. With a number of approximations which, although plausible, are hard to justify rigorously, an estimate is made of the relative contributions to the amplitude coming from the angular momentum cut and the corresponding Regge pole. (Disser. Abstr.)

Particle Accelerators

Refer also to abstracts 3235 and 3601.

3553 (CEA-R-3126) ETUDE DES PROPRIETES DU FAISCEAU D'ELECTRONS D'UN ACCELERATEUR LINEAIRE AU MOYEN DES CHAMPS ELECTROMAGNETIQUES ASSOCIES A CE FAISCEAU. (Study of the Properties of an Electron Linac Beam by Means of the Electromagnetic Fields Associated with the Beam). Bergere, Roland (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). 1967. 205p. (In French). Dep.

Thesis. Submitted to Univ. of Paris, Faculte des Sciences, Orsay, France.

For measuring the diverse characteristic parameters of a linac electron beam, the one method causing the least perturbation to the electron beam itself, consists in the detection of signals induced in certain types of detectors by the electromagnetic fields associated with the beam. Some particular detectors are then described, for measuring the following characteristic parameters of a linac electron beam: electron beam peak current, longitudinal dimension and density of an elementary electron bunch, phase position of the electrons on the travelling sine wave of the accelerating field, and transverse position of the beam. These particular electrodes are then used to provide experimental data in order to check the theoretical computations giving the longitudinal and transversal motions of the electrons during their acceleration. (auth)

3554 (CERN-66-29(Vol.3), pp 153-65) EXPERIMENTAL POSSIBILITIES WITH PROTON INTERSECTING STORAGE RINGS. Hyams, B. D. (European Organization for Nuclear Research, Geneva (Switzerland)).

The basic reasons for building proton intersecting storage rings (ISR) are reviewed. ISR parameters, the problem of background, and fields of experimental investigation are covered. It is found that there are many experiments to be performed using the proton ISR, that they will provide the highest jump in energy undertaken. It is observed that there is a lack of preparation for experiments at 50 GeV cm since too few were previously performed at 5 GeV cm. (J.F.P.)

3555 (CERN-67-22) SUR LA THEORIE DU QUADRUPLET DE RETOURNEMENT. (On the Theory of the Turn-Over Quadruplet). Regenstreif, E. (European Organization for Nuclear Research, Geneva (Switzerland)). Aug. 28, 1967. 68p. (In French). Dep.

The basic parameters of a reversal device for a high-energy h-f separator are established. The limits between which the geometric and electric parameters of a quadrupole quadruplet when it is to furnish a reversal situation at the same time as real and stigmatic images were determined. The normal reversal quadruplet composed of elements having the same length and gradient was the object of a more extensive investigation and the relations derived permit in principle the establishment of the design of reversal optics simultaneously associated with an hf separator. (tr-auth)

3556 (CERN-67-29) PERIODS OF PHASE OSCILLATIONS AS A FUNCTION OF AMPLITUDE. Koziol, H. (European Organization for Nuclear Research, Geneva (Switzerland)). Oct. 2, 1967. 23p. Dep.

Particles contained in an rf-bucket will perform nonlinear oscillations around the stable phase angle. At infinitely small amplitudes, i.e. for particles very near to the phase stable point, these oscillations can be regarded to be linear and the period is a simple function of $\Gamma = -\sin\phi_s$. For finite amplitudes the period can be calculated by numerical integration. The dependence of the phase oscillation period $\Theta(\Gamma,\kappa)$ on Γ and amplitude κ is presented in graphical and tabulated form. (auth)

3557 (HASL-188) NEUTRON SHIELDING OF THE LOS ALAMOS MESON PHYSICS FACILITY. O'Brien, Keran (New York Operations Office (AEC), N. Y. Health and Safety Lab.). Nov. 1967. 11p. Dep. CFSTI.

Neutron fluxes and dose-equivalent rates in the lateral shielding of the Los Alamos Meson Physics Facility were calculated using neutron cascade theory. Two values of the hydrogen atom concentration were assumed, to test the sensitivity of neutron dose-rates to the water content. The lateral shielding of the accelerator, which is of earth, was assumed to have an average atomic number of 13. (auth)

3558 (JINR-P9-3497) ELEKTRICHESKOE POLE V TSENTRAL'NOI OBLASTI SINKHROTSIKLOTRONA. (Electric Field in the Central Region of the Synchrocyclotron). Danilov, V. I.; Puzynin, I. V. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1967. 41p. (In Russian). Dep.

Main features of the distribution of the electric field, which is induced between accelerating electrodes in the central region of the synchrocyclotron, are investigated. It is necessary to know the components of the electric field in order to formulate and solve the problems of the phase motion and the effect of space charge on the initial process of acceleration taking into account the dependence of the electric field amplitude not only on time but also on the space coordinates. (auth)

3559 (LAL-1176) RAPPORT D'ACTIVITE LER MAI 1966-LER MAI 1967. (Report of Activity, May 1966-May 1967). (Paris Univ., Orsay (France). Laboratoire de l'Accelerateur Lineaire). June 1967. 53p. (In French). Dep.

The improvement and utilization of the linear accelerator are summarized, together with research progress in nuclear physics, particle physics, storage rings, and the physics of bubble chambers. Development of associated experimental equipment and radiation control are reported. A bibliography of the publications during this period is appended. (J.S.R.)

3560 (NP-17013) UKOROCHENIE TOKOVOGO IMPUL'SA NA DVUKHSEKTS IONNOM LINEINOM USKORITELE. (Shortening the Current Pulse in a Two-Section Linear Accelerator). Vishnyakov, V. A.; Zykov, A. I.; Grizhko, V. M.; Grishaev, I. A. (Akademiya Nauk Ukrainskoi SSR, Kharkov. Fiziko-Tekhnicheskii Institut). 1966. 11p. (In Russian). Dep.

The experimental study of the effect of various factors on the character of the beam break-down was reported. The results were compared with calculated effects. The methods used for determination of the critical current are described. The dependence of the critical current on the electron energy and the pulse duration was determined. The dependence of the critical current on the length of the diaphragm wave guide was also measured. (J.S.R.)

3561 (ORNL-TM-2004) INFORMATION GUIDE FOR USERS OF THE OAK RIDGE ISOCHRONOUS CYCLOTRON. [Howard, F. T.] (Oak Ridge National Lab., Tenn.). Nov. 1967. Contract W-7405-eng-26. 25p. Dep. CFSTI.

A statement of policy in regard to the availability of the research facilities of the ORIC and the procedures developed to facilitate their use is presented. The facilities are briefly described. (W.H.K.)

3562 (UCRL-17728) RAPID BEAM CUTOFF FOR 88-INCH CYCLOTRON. Dakin, Henry S.; Wadman III, William W. (California Univ., Berkeley. Lawrence Radiation Lab.). May 1, 1967. Contract W-7405-eng-48. 10p. Dep. CFSTI.

The design and operation of an electronic system is described which, upon an unexpected rise in cyclotron-produced radiation intensity, simultaneously sounds an alarm and deactivates the radiation source within 2×10^{-6} sec. (auth)

3563 (UCRL-17796) CONTROL OF THE CLOSED ORBIT IN SYNCHROTRONS BY DISPLACEMENT OF MAGNETS. Lambertson, G. R.; Laslett, L. Jackson (California Univ., Berkeley. Lawrence Radiation Lab.). Sept. 6, 1967. Contract W-7405-eng-48. 8p. (CONF-670930-18). Dep. CFSTI.

From 6th International Conference on High Energy Accelerators, Cambridge, Mass.

A study of the effectiveness of magnet positional adjustments in the synchrotron as a corrective system for alignment of a closed orbit is discussed. Data on orbit displacements and the effects of noise are presented. (W.H.K.)

3564 NIER-TYPE ELECTRON BOMBARDMENT ION SOURCE WITHOUT SOURCE AUXILIARY MAGNETIC FIELD. STUDY OF THE OPTIMUM OPERATING CONDITIONS OF THE ELECTRON ACCELERATOR SYSTEM. Chantreau, Jean (Faculte des Sciences, Poitiers, France). Compt. Rend., Ser. A and B, 265: 176-9(July 17, 1967). (In French).

The focussing conditions of the ionizing electron beam and the possibilities of realizing a practically afocal bundle of minimum thickness, integrally collected by the Trappe electrode, were studied. The experimental results for accelerating voltages between 100 and 1000 v and electron currents up to 50 μamp agree with the conclusions drawn from the theoretical study of the electron trajectories in the source. (tr-auth)

3565 CNEN'S FRASCATI NATIONAL LABORATORIES. THE ELECTROSYNCHROTRON. Com. Naz. Energ. Nucl., Notiz., 13: No. 8-9, 56-71(Aug.-Sept. 1967). (In Italian).

After some introductory comments on the operating principle of this machine, the latter, which has been in operation since 1959, is described in detail. (auth)

3566 CNEN'S FRASCATI NATIONAL LABORATORIES. Com. Naz. Energ. Nucl., Notiz., 13: No. 8-9, 47-55(Aug.-Sept. 1967). (In Italian).

The introductory section, after a short history of C.N.E.N.'s Frascati National Laboratories since their foundation, reviews the research conducted and the programs now in progress or planned. (auth)

3567 STUDY OF THE COMPOSITION AND ENERGY DISPERSION OF A BEAM OF POSITIVE IONS EXTRACTED FROM A PENNING-TYPE SOURCE. Perdrix, M.; Paletto, S.; Goutte, R.; Guillaud, C. (Institut National des Sciences Appliquees, Villeurbanne, France). Vide, 22: 189-95(July-Aug. 1967). (In French).

A Penning type ion source giving a total ionic positive current of the order of 50-100 μA is described. The different ions in the beam are separated by a magnetic field and the spectra for argon, nitrogen, neon, helium and hydrogen are given. Lastly the energy dispersion of the ions as a function of the different parameters is studied. (auth)

3568 EXPERIMENTAL STUDY OF THE TRANSITORY RESPONSE OF AN IRISED ACCELERATING CAVITY, EXCITED BY A PULSE-MODULATED HYPERFREQUENCY WAVE. Marcou, Jacques; Papiernik, Albert; Wartski, Louis (Faculte des Sciences, Orsay, France). Compt. Rend., Ser. A and B, 265: 172-5(July 17, 1967). (In French).

The response of an irised structure to external perturbation was studied by constructing a chamber permitting the observation of the transitory phenomena in a cavity constituted by an irised guide portion what can be excited by a pulse-modulated wave or by injecting a continuous or modulated electron beam into the cavity fed permanently by a hyperfrequency wave. The design of the cavity and hyperfrequency circuits is described. Figures show the relative response to the $2\pi/3$ mode. The comparison establishes that the phenomena front is propagated at the group velocity relative to this mode. With time the increase of the amplitude at each point is made by successive plateaus. The rise time agrees with the theoretical predictions, but the amplitude of the oscillations around the mean value are below theoretical predictions. The comparison of the responses relative to the different modes shows that the wide variations of amplitude, with respect to the successive reflections are more important as the π mode is approached. The duration of transitory phenomena is at a minimum for the $\pi/3$ mode. The comparison between fundamental modes of same group velocity does not agree with theory. (J.S.R.)

3569 CNEN'S FRASCATI NATIONAL LABORATORIES. THE EXPERIMENTS WITH THE ELECTROSYNCHROTRON. Com. Naz. Energ. Nucl., Notiz., 13: No. 8-9, 72-86(Aug.-Sept. 1967). (In Italian).

A discussion is presented of the detection devices, characteristics of particle beams and the principal experiments conducted. (auth)

3570 CNEN'S FRASCATI NATIONAL LABORATORIES. ADA AND ADONE. Com. Naz. Energ. Nucl., Notiz., 13: No. 8-9, 87-103(Aug.-Sept. 1967). (In Italian).

A description is presented of the 250-MeV Ada storage ring in operation since 1961 and of the 1.5 GeV Adone storage ring which will soon be put into service. (auth)

3571 CNEN'S FRASCATI NATIONAL LABORATORIES. PROJECT LEALE. Com. Naz. Energy. Nucl., Notiz., 13: No. 8-9, 104-6(Aug.-Sept. 1967). (In Italian).

Project Leale (from the Italian initials of Linear Electron Accelerator Experimental Laboratory) related to the Adone injection linear accelerator which, according to the decisions adopted by the Management Council of the I.N.F.N. in 1962, and is designed to operate also independently of the storage ring is described. (auth)

3572 CNEN'S FRASCATI NATIONAL LABORATORIES. SUPPORT AND NON-NUCLEAR RESEARCH GROUPS. Com. Naz. Energ. Nucl., Notiz., 13: No. 8-9, 109-24(Aug.-Sept. 1967). (In Italian).

These groups are established principally to conduct auxiliary activities in the field of nuclear fission and to develop the instrumentation required for research with the electrosynchrotron, with the Adone storage ring and with the beam from Project Leale's linear accelerator. (auth)

3573 NEW 200-GeV DESIGN PUTS U.S. OUT FRONT. Davis, Harold L. Sci. Res., 2: No. 11, 48-50(Nov. 1967).

A brief discussion is presented on the economic aspects involved with developing a multi-GeV accelerator. A method for decreasing the cost of these machines, based on the use of separated-function magnets in the main ring, is described. (B.G.D.)

3574 THE ELECTRON-SCATTERING FACILITY AT THE SASKATCHEWAN ACCELERATOR LABORATORY. Katz, L.; Beer, G. A.; McArthur, D. E.; Caplan, H. S. (Saskatchewan Accelerator Lab., Saskatoon). Can. J. Phys., 45: 3721-36 (Nov. 1967).

The accelerator, beam handling system, magnetic spectrometer, and other equipment used to perform electron-scattering experiments are described. The nuclear information which can be obtained from such experiments is also discussed. (auth)

3575 APERIODIC MAGNET COILS OF FREQUENCY-MODULATED POWER OSCILLATOR FOR FEEDING ACCELERATING RESONATORS OF SYNCHROTRONS. Nezhevenko, O. A.; Ostreiko, G. N.; Panasyuk, V. S.; Yudin, L. I. (Inst. of Nuclear Physics, Novosibirsk, USSR). Prib. Tekh. Eksp., No. 2, 17-20(Mar.-Apr. 1967). (In Russian).

Two types of ferrite magnet coils for meter-wave f-m power oscillators used for feeding resonators of synchrotrons were described. The method for eliminating natural resonances in the multiturn magnet coil, when its total length comprises an integral number of wave lengths, was reported. (tr-auth)

3576 SHAPE OF ELECTRODES MEASURING THE SHIFT OF CHARGED PARTICLE BEAM. Gol'din, L. L.; Kuz'min, A. A. (Inst. of Theoretical and Experimental Physics, Moscow). Prib. Tekh. Eksp., No. 2, 27-30(Mar.-Apr. 1967). (In Russian).

The rules, used to find the shape of electrodes needed for measuring the shift of the center of gravity of a beam of charged particles in a chamber of arbitrary cross section, were given. (tr-auth)

3577 NA-2 NEUTRON GENERATOR AND ITS APPLICATIONS. Pasztor, E. (Central Research Inst. of Physics, Budapest). Isotopenpraxis, 3: 259-61(July 1967).

The NA-2 neutron generator was described by E. Pasztor and E. Klopfer in Instr. Techn. Exp., Vol 1965, No 4, p 36. Some modifications in the design of this neutron generator are discussed. These modifications involve the high-voltage electrode assembly (where the space occupied by the assembly was reduced), the cooling system (made more efficient by the reduction in size of the electrode assembly), insertion of a 1000-Hz chopper system (to produce pulses of 20 μsec width), and an increase in the size of the target, and increasing the neutron yield. The advantages resulting from these modifications were discussed with especial emphasis on improved performance in activation analysis studies. (JPRS)

3578 ACCELERATING TUBE WITH OBLIQUE FIELDS FOR AN ELECTROSTATIC ACCELERATOR. Serbinov, A. N.; Romanov, V. A. Izobret., Prom. Obraztsy, Tovarnye Znaki, No. 1, 70(1966).

An accelerating tube with oblique fields for an electrostatic accelerator is described. To ensure a constant trajectory of the ion beam with variation of the accelerating voltage, the tube has a preliminary acceleration section with flat electrodes and a compensating section with oblique electrodes. An electrostatic corrector connected to the high voltage divider of the tube is placed at the output of the tube. (JPRS)

3579 ELECTRON GUN OF A HIGH-PRECISION PROTON ACCELERATOR MODEL. Glazov, A. A.; Novikov, D. L. (Joint Inst. for Nuclear Research, Dubna, USSR). Prib. Tekh. Eksp., No. 2, 33-5(Mar.-Apr. 1967). (In Russian).

The construction and basic parameters of the spherical electron gun injector of a high-precision proton accelerator model (relativistic cyclotron), designed for examination of the dynamic processes of acceleration and escape of particles, were described. The gun operates in a continuous regime with perveance $P = 1.25 \times 10^{-6}$ a/e$^{3/2}$. Tablets of LaB_6 with thickness 1 and ϕ10 mm were used as the gun cathode. The cathode was heated by electron bombardment. The elements of the gun were separated by Teflon washers, which simultaneously act as high-voltage insulator and wall of the vacuum chamber. A similar composite construction was used to change the spacing between the gun electrodes, guaranteeing the high precision of the optical system. (tr-auth)

3580 COMPOSITION OF THE ION BEAM EMITTED BY A HIGH-FREQUENCY ION SOURCE. Liebich, W.; Pose, H. (Technische Univ., Dresden). Exp. Tech. Phys., No. 6, 353-7 (1966). (In German).

The dependence of the composition of the ion beam emitted by a high-frequency ion source on probe potential and gas pressure was investigated experimentally. The ion source was connected to a three-stage accelerating system of a 500-keV cascade generator, and a hydrogen–deuterium mixture was the working gas. A 90° beam deflection magnet (0.3 m orbit radius) was used as the analyzer magnet for the accelerated particle beam. The measuring trap system (0.015 m in diameter) was at a distance of 0.75 m from the deflection magnet's outlet edge. Gas discharge excitation proceeded magnetically. It was shown that the high-frequency source satisfied fairly well the conditions of long service life at constant beam required of a low-voltage ion accelerator. Previous particle beam measurements performed with the high-frequency 150-keV deuteron accelerator operated at the Institute of Experimental Nuclear Physics in Dresden for more than 3 years are in accord qualitatively with the measurements reported, and prove the stability of such installations over longer periods of time. (JPRS)

3581 PROGRAMMING THE ACCELERATING VOLTAGE AMPLITUDE OF A MODEL OF THE CIRCULAR PROTON PHASOTRON RF SYSTEM. Glazov, A. A.; Shvabe, E. (Joint Inst. for Nuclear Research, Dubna, USSR). Nukleonika, 12: 515-36(1967). (In Russian).

The results of programming the accelerating voltage amplitude of the model of the circular proton phasotron rf system are reported. By using the self-anode modulation circuit of the powerful oscillator the programming of the accelerating voltage amplitude is carried out by means of a low-powered and simple modulator. The conditions of modulation linearity considered theoretically were proved experimentally. (auth)

3582 EXPERIMENTAL INVESTIGATION OF THE ELECTRODYNAMICS OF POST-TYPE ACCELERATING SYSTEM FOR WAVEGUIDE SYNCHROTRON. Gos'kov, P. I. (Tomsk Polytechnic Inst., USSR). Izv. Vyssh. Ucheb. Zaved., Fiz., No. 6, 157-8(1967). (In Russian).

It is shown that the slow-wave structures used in waveguide-type accelerators are too complex to be designed analytically, so that most of their parameters must be determined from experiment. To facilitate the experiments, a kit has been developed of easily constructed waveguide parts, which can be assembled into post-type slow-wave models. The kit consists of a set of posts of different heights and cross section, a set of interchangeable waveguide covers, and a number of waveguides of different widths. The parts of the kit can be used to make up single two-row and one-row ridge structures, ladder structures, etc. These can be further modified by using various interchangeable inserts. The models constructed from the kit parts had a Q on the order of 1000-2500, which is adequate for most experiments. Disassembly and reassembly of the same model changed the resonant frequency by less than 0.01% and did not affect the Q. The kit was used to study the electrodynamic parameters of a number of proposed designs for iron-free synchrotron of several GeV energy. Some of the results have also been published in (Atomnaya energiya v. 18, 3, 275, 1965 and Izv. vuzov SSSR, Fizika, no. 3, 61, 1965). (ATD)

3583 PROCESSES OCCURRING DURING THE MOVEMENT OF HIGH ENERGY PARTICLES IN A MAGNETIC FIELD. Baier, V. N.; Katkov, V. M. (Novosibirsk State Univ., USSR). Zh. Eksp. Teor. Fiz., 53: 1478-91(Oct. 1967). (In Russian).

An operator method is proposed for studying quantum effects arising during the motion of charged particles in a magnetic field. The method is valid for processes in an arbitrary field and for particles with an arbitrary spin. The method is employed for studying quantum phenomena in magnet-bremsstrahlung radiation and also particle pair production by photons and single-photon annihilation of particle pairs. (auth)

3584 PRECISE METHODS FOR PRE-CALCULATION OF CYCLOTRON CONTROL SETTINGS. Berg, Richard Eugene. East Lansing, Mich., Michigan State Univ., 1966. 135p.

Thesis.

A computer program, SETOP, has been written which uses measured magnetic fields and a precomputed set of ideal average fields to determine operating points for the MSU variable-energy, multiparticle cyclotron; to obtain a complete set of operating instructions, the experimenter need only specify the particle and energy of interest. Control settings are computed in a straightforward sequence of operations: the fields at the desired excitation are synthesized by interpolation in the measured field data, an average field is obtained using a modified least squares fit of the desired average field by the trim coils, and the rf frequency is determined so as to minimize the energy spread of the beam in a single turn at the extraction energy. Independent numerical orbit studies were employed to investigate important features of the separated longitudinal equations of motion as used in SETOP, and several diagnostic procedures were investigated using numerical orbit integration to establish their validity under conditions obtained in the MSU cyclotron. Finally, the results of experimental measurements of several dynamical beam properties are presented which are in excellent agreement with pre-computed values. (Disser. Abstr.)

PHYSICS (NUCLEAR)

Neutron Interactions with Matter

Refer also to abstracts 3577 and 3745.

3585 (AED-C-34-02) BIBLIOGRAPHIEN ZUR KERNFORSCHUNG UND KERNTECHNIK. SEKTION 34. RECHENPROGRAMME IN DER KERNPHYSIK. Nummer 02. (Bibliographies in Nuclear Science and Technology. Section 34. Computer Programs in Nuclear Physics. Number 02). Wittig, Siegmar (comp.) (Zentralstelle fuer Atomkernenergie-Dokumentation, Frankfurt am Main (West Germany)). June 1967. 152p. (In English and German). Dep.

A bibliography (468 references) of computer programs for nuclear and reactor physics is presented. Entries dealing with computers, computational methods, data processing, and other assorted topics are also included as are author, report number, and subject indexes. (D.C.W.)

3586 (BNL-50066) ENDF/B: SPECIFICATIONS FOR AN EVALUATED NUCLEAR DATA FILE FOR REACTOR APPLICATIONS. Honeck, Henry C. (Brookhaven National Lab., Upton, N. Y.). May 1966. Revised July 1967. 115p. Dep. CFSTI.

The organization and operation of the ENDF/B system which is primarily intended to be a binary magnetic tape format for use as the main input to a cross-section processing program are described. A punched card format, equivalent to the tape format, is provided. (D.C.W.)

3587 (GA-7647) DIFFERENTIAL NEUTRON THERMALIZATION. Quarterly Technical Report, October 1–December 31, 1966. Whittemore, W. L. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). Jan. 17, 1967. Contract AT-(04-3)-167. 17p. Dep. CFSTI.

The pulse widths of thermalized neutron beams were investigated. Fast neutrons from an electron beam-target source were passed into a moderating assembly, and the leakage thermal neutrons were analyzed using either a chopper located halfway between the source of thermal neutron and the detectors or by a time-of-flight crystal technique. Results are presented for neutrons emitted from CH_2 and liquid parahydrogen. Further analysis of scattering law data for graphite was also performed. (D.C.W.)

3588 (GA-8203) STUDY OF TWO-LEVEL INTERFERENCE IN NEUTRON CROSS SECTIONS. Garrison, J. D.; Freeman, R. A. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). Sept. 1, 1967. 227p. CFSTI.

Interference between resonances in neutron cross sections was studied using the two-level approximation. Sample cross sections indicating a wide variety of interference conditions were calculated and were plotted using the equations obtained from R-matrix theory. The mathematical connection between the R-matrix and the Kapur–Peierl theories provides two sets of resonance parameters for each cross-section calculation, allowing a numerical measure of the effects of interference. Statistical distributions of the Kapur–Peierl parameters for various interference conditions and the mathematical properties of the cross section when the resonance widths are large compared to the spacing were also obtained. (auth)

3589 (JUL-484-RE) STRENGE LOESUNG DER ENERGIEUNABHAENGIGEN NEUTRONENTRANSPORTGLEICHUNG FUER EINE DUENNE EINGEBETTETE SCHICHT. (Rigorous Solution of the Energy-Independent Neutron Transport Equation for a Thin Imbedded Layer). Meister, G. (Kernforschungsanlage, Juelich (West Germany). Zentralabteilung Forschungsreaktoren). May 1967. 44p. (In German). Dep.

The problem of the neutron distribution in a medium whose dimensions are not large with respect to the mean free path of neutrons in the medium was theoretically investigated. A thin homogeneous layer which is imbedded in an infinitely expanding medium with other transport properties was considered. For this case, under the assumption of isotropic scattering, the energy-independent source-free neutron transport equation was solved exactly; and formulas for the spatial distribution of the neutron flux density and the net neutron current were derived. The eigenfunction method developed by K. M. Case was used as the analytical method. (tr-auth)

3590 (MLM-1422) NEUTRON ENERGY SPECTRA OF ^{239}Pu–Be, ^{238}Pu–F, AND ^{238}Pu–$^{18}O(\alpha,n)$ SOURCES. Anderson, M. E. (Mound Lab., Miamisburg, Ohio). Feb. 4, 1967. Contract AT(33-1)-Gen-53. 12p. Dep. CFSTI.

The energy spectra of isotopic neutron sources are being determined with a single stilbene crystal, fast neutron spectrometer. Pulse shape discrimination is used to separate pulses originating from neutron interaction and those originating from gamma interactions. Spectra were obtained for (α,n) sources containing ^{239}Pu with Be, ^{238}Pu with F, and ^{238}Pu with ^{18}O. (auth)

3591 (ORNL-TM-1819) CALCULATIONS OF THE EFFECT OF THE AIR-GROUND INTERFACE ON THE TRANSPORT OF FISSION NEUTRONS THROUGH THE ATMOSPHERE. Straker, E. A.; Mynatt, F. R. (Oak Ridge National Lab., Tenn.). Nov. 1, 1967. Contract W-7405-eng-26. 21p.

Two-dimensional discrete ordinates calculations of neutron transport in an air-over-ground geometry were performed for three different ground compositions. Results for a neutron fission source at 92 meters above the interface are compared with infinite air results. The calculated values of dose and thermal flux for both a fission and a Godiva leakage spectrum are compared with results from Operation BREN. Although the ground interface has a significant effect on the transport, the hydrogen content of the ground also has a large effect. Agreement between calculations and the BREN results is satisfactory when the Godiva leakage spectrum is used. (auth)

3592 (RPI-328-101) RECENT LOW ENERGY INELASTIC SCATTERING RESULTS FOR METAL HYDRIDES AND URANIUM CARBIDE. Pan, S. S.; Yeater, M. L. (Rensselaer Polytechnic Inst., Troy, N. Y.); Moore, W. E. (Knolls Atomic Power Lab., Schenectady, N. Y.). [1967]. Contract AT(30-3)-328. 11p. (CONF-671028-4). Dep. CFSTI.

From 2nd Symposium on Materials Research: Molecular Dynamics and Structure of Solids, Gaithersburg, Md.

Measurements of the inelastic scattering of neutrons by metal hydrides were made using the RPI-KAPL neutron spectrometer. The data studied include room temperature measurements of ZrH_x (x variable), NbH and TiH_1. Measurements were completed also for NbH and ZrH_2 at liquid nitrogen temperature. Incomplete data were obtained for thorium and yttrium hydrides. For zirconium hydride, the dependence of optical level width on sample temperature, momentum transfer and concentration of hydrogen was studied. NbH data exhibit a doublet at 0.12 and 0.164 eV which is believed to arise from splitting of the 1-0 transition in the optical band into transverse and longitudinal modes. New evidence was obtained for NbH regarding the relative weight of acoustic and optical modes in the frequency distribution. In general, the frequency distributions can not be approximated by simple Einstein oscillators. (auth)

3593 SOLUTION OF THE TIME-DEPENDENT BOLTZMANN EQUATION FOR MONOENERGETIC NEUTRONS IN CYLINDRICAL GEOMETRY. Bianco, Antonio (Inst. of Nuclear Research, Swierk, Poland). Nukleonika, 12: 459-70(1967).

The spectral properties of the Boltzmann operator for monoenergetic neutrons in an infinite cylinder are considered. The continuous spectrum exists for the half-plane $\mathrm{Re}\,\lambda \leq -\nu_0\sigma_T$. The point spectrum consists of a finite number of real eigenvalues located on the right of the line $\mathrm{Re}\,\lambda = -\nu_0\sigma_T$. For the point spectrum, the integro-differential Boltzmann operator is equivalent to the compact integral operator. The initial-value problem is formally solved by the application of the theory of semigroups of operators. (auth)

3594 NEUTRON DIFFUSION USING A MODULATED SOURCE. Massel, G. A. (Langley Research Center, Hampton, Va.); Feix, M. R. Nucl. Sci. Eng., 30: 455-61(1967).

A theoretical analysis of the modulated source technique is presented considering a one-dimensional system of infinite extent with a uniform monoenergetic emitter at the origin. The medium is characterized as a homogeneous isotropic scatterer that is symmetric about the plane x = 0. (D.C.W.)

3595 MILNE'S PROBLEM WITH ANISOTROPIC SCATTERING AND RELATED PROBLEMS. Maslennikov, M. V. (Inst. of Applied Mathematics, Moscow). At. Energy Rev., 5: No. 2, 59-158(1967).

The main results of the mathematical theory of the passage of monochromatic radiation through finite or semi-infinite plane-parallel layers of material are given. The single scattering of the radiation by the material is assumed to be anisotropic. Work on similar problems involving isotropic scattering is not dealt with. The main subjects discussed are the qualitative investigation of

Milne's problem with a fairly general law of single (solubility of the problem, properties of its solutions, asymptotic formulas, etc.) and some analytical methods of solving it. Among the questions related to Milne's problem, the review discusses the inverse problem of the asymptotic radiation transport theory, the asymptotic properties of solutions to problems dealing with the passage of radiation through finite plane layers of great optical thickness, the theory of the characteristic equation, and some numerical methods of solving problems of transport theory with anisotropic scattering. (auth)

3596 AN EXTENDED TABLE OF CALCULATED (n,2n) CROSS SECTIONS. Pearlstein, S. (Brookhaven National Lab., Upton, N. Y.). Nucl. Data, Sect. A 3: 327-41(Oct. 1967). (BNL-11505).

Computed values of the (n,2n) cross sections of 500 stable and unstable targets are presented for three neutron energies in the neighborhood of 14 MeV and for a fission neutron spectrum. Cross sections for the (n,3n) reaction induced by fission neutrons are also given. The calculations are based on the statistical model and on empirical expressions for inelastic cross sections and level density. (D.C.W.)

3597 DECAY OF THERMALIZED NEUTRON FIELDS IN GRAPHITE. Reed, C. H.; Henry, C. N.; Usner, A. A. (Los Alamos Scientific Lab., N. Mex.). Contract W-7405-eng-36. Nucl. Sci. Eng., 30: 362-73(1967). (LA-DC-8736).

Asymptotic decay constants for pulse-induced "thermalized" neutron fields were measured for graphite cubical assemblies having geometric bucklings varying from 9.30×10^{-4} to 13.44×10^{-3} cm^{-2}. A value of 700 μ sec was observed to be a sufficient time after the neutron pulse to identify and evaluate fundamental-mode decay in the smallest system included in the above interval of buckling. Values of the infinite-medium neutron lifetime $l = (\overline{\Sigma a \nu})^{-1}$, "Fick's-law" diffusion coefficient D_0, as well as the so-called "diffusion-cooling" coefficient C, were obtained from least-squares fits to the experimental α/ρ vs B^2/ρ^2 data and are mutually consistent and stable over a large interval of B^2 and in good agreement with theory. The existence of a well-difined negative FB^6 term has been verified. An "effective" higher-mode decay of 3570 ± 80 sec^{-1}, independent of system buckling, was obtained and is consistent with the concept of a continuum lying above a critical limit for fundamental-mode decay. An apparent critical limit $(\nu\Sigma_c)_{min}$ was identified in the interval 2392 sec^{-1} < $(\nu\Sigma_c)_{min}$ < 2648 sec^{-1} which corresponds to the interval of buckling 13.44×10^{-3} to 16.53×10^{-3} cm^{-2}. 23 references. (auth)

3598 CALCULATION AND INTERPRETATION OF NEUTRON THERMALIZATION IN FINITE BLOCKS OF BERYLLIUM. Lee, Robert Roy. Troy, N. Y., Rensselaer Polytechnic Inst., 1966. 143p.

Thesis.

This theoretical investigation of the time dependence of a neutron pulse in finite beryllium assemblies uses the eigenvalue-eigenfunction method, with the energy treated as a discrete ordinate, to analyze experimental measurements in the buckling range B^2 = 0.0131 cm^{-2} to 0.124 cm^{-2}. For assembly sizes that do not have a discrete or asymptotic mode (B^2 > .03 cm^{-2}), the time-dependent flux is shown to be dominated by a pseudo-fundamental eigenvalue-eigenfunction that is actually part of the continuum spectrum. This gives rise to an essentially single exponential decay of the time dependent flux in the time range of interest to the experimenter and is a quantitative explanation of why measured eigenvalues for small systems appear to violate the continuum limit, $(\nu\Sigma)_{min}$. The pseudo-fundamental eigenfunction has peaks corresponding to Bragg peaks in the cross section and describes a trapping of neutrons at these energies. Spatial effects are examined with the P-1 approximation and a Marshak boundary condition. They are seen to be important for assemblies with no discrete eigenvalue. The inclusion of a Marshak boundary condition results in an improved agreement with experiment and a three to five percent change in eigenvalues and eigenfunctions from the zero flux boundary condition results. Transport effects are examined with a P-3 calculation, which gives eigenvalues close to the P-1 results. P-3 eigenfunctions show a marked difference at low energies where the mean free path of neutrons is comparable to the assembly dimensions. The incoherent approximation is used to describe the isotropic scattering and reproduces the main features of experimental measurements, but is seen to be incorrect at energies near the Bragg cutoff (.005 eV), with the experimental and theoretical flux peaks at the major Bragg energy (.0068 eV) differing by as much as twenty percent in the smaller assemblies when normalized at high energies. The theoretical decay constants are from five to fifteen percent below the corresponding experimental values, the discrepancy becoming larger as the size of the assembly is decreased. The free gas isotropic kernel is shown to be completely inadequate for time-dependent problems in beryllium. Low-order angular approximations to the transport equation appear to be adequate for the calculation of neutron behavior in the assemblies considered in this investigation. The largest differences between experiment and theory appear to be due to inadequacies in the scattering kernel. (Disser. Abstr.)

3599 COUPLED REACTORS KINETICS EQUATIONS. Plaza-Rosado, Heriberto. College Station, Tex., Texas A and M Univ., 1966. 111p.

Thesis.

A general formulation of the kinetics equations of a system of coupled reactors is developed within the framework of neutron transport theory. The time behavior of the neutron population in a system of M interacting reactors is described by a set of M coupled generalized point kinetics equations. The kinetic behavior in each reactor being determined partly by its own characteristics and partly by the neutronic contribution from the rest of the system. The method of approach consists of describing the neutron population within a reactor by a single equation, the time-dependent transport equation, and classifying neutrons on the surface of the reactor by groups according to the particular direction they travel with respect to a unit normal at the surface. This permits the use of the concept of surface coupling to account for the neutronic interaction between the reactors. To obtain the kinetics equation of the jth reactor in the system an adjoint equation is formulated in conjunction with the time dependent transport equation. The adjoint equation describes a fictitious steady state in the jth reactor when isolated from its environment. The mathematical procedure to derive the kinetics equations is basically the same as that used in formulating generalized point kinetics equations. The coupled reactors kinetics equations are cast in terms of an amplitude time function and the reactor parameters defined as functions of a time-dependent space flux shape. The generalized point kinetics equations for bare and reflected reactors are deduced from the coupled reactors formulation. The fact that the angular flux is partitioned into an amplitude time function and a time-dependent space flux shape makes the formulation suitable to describe space-time non-separable situations. Once the kinetics equations are formulated consideration is given to the calculation of the parameters appearing in the equations. In particular, a multigroup-spherical harmonics approximation is used in evaluating the reactor parameters. Also, computational techniques to calculate the coupling coefficients as well as the average delay times for systems of loosely coupled reactors are introduced. In order to illustrate the application of the theoretical results the solution of the kinetics equations for a system of M interacting reactors, in the case of constant reactor perturbations, is presented. A qualitative description of the time behavior in a two-reactor system is given in terms of the real roots of the inhour equation. These results are supplemented by conducting numerical experiments to investigate the kinetic behavior of a weakly coupled two-reactor system in slab geometry. A three-group diffusion approximation is used in computing coupling and reactor parameters. The results obtained demonstrate that a system of coupled reactors may exhibit a positive asymptotic period even though the sum of all the reactivities in all reactors of the system is negative. (Disser. Abstr.)

Nuclear Properties and Reactions, A≤ 5

Refer also to abstracts 3256 and 3465.

3600 (p,d) REACTIONS WITH ^{6}Li, ^{7}Li, AND ^{9}Be. Kull, L. A. (Michigan State Univ., East Lansing). Phys. Rev., 163: 1066-73(Nov. 20, 1967).

Excited states of ^{5}Li, ^{6}Li, and ^{9}Be were studied by means of the (p,d) reaction, using 33.6-MeV incident protons. Deuteron groups were observed corresponding to strongly excited levels in ^{5}Li at 0.0 and 16.6 MeV; in ^{6}Li at 0.0, 2.15, 3.57, and 5.38 MeV; and in ^{9}Be at 0.0, 3.1, 11.4, 16.95, 17.62, 18.18, and 19.21 MeV. Small deuteron yields were observed for excited levels of ^{9}Be at 16.6 and 19.15 MeV. Angular distributions were taken for the strongly excited states, and the results were compared with a distorted-wave Born-approximation (DWBA) calculation. Angular distributions for the elastic scattering of 33.6-MeV protons from targets of ^{6}Li, ^{7}Li, and ^{9}Be were measured and fitted with an optical-model calculation to obtain the proton optical parameters used in the DWBA analysis. With a few exceptions, which are discussed, the (p,d) angular distributions are characteristic of a direct pickup of a 1p-shell neutron. Spectroscopic factors were extracted from the experimental data and were compared with those obtained from theoretical intermediate-coupling calculations in the 1p shell. The results are discussed for the high excited states of ^{9}Be, where isotopic-spin mixing is indicated. (auth)

3601 DYNAMIC POLARIZATION OF PROTONS IN IRRADIATED POLYMERS. Burget, J.; Petricek, V.; Sacha, J.; Tichy, R. (Nuclear Research Inst., Czechoslovak Academy of Sciences, Rez). Czech. J. Phys., B17: 1041-7(1967).

Protons were polarized in different types of irradiated polymers by means of the "solid effect" method. The polarization was measured in fields of 3,150 Oe and 19,200 Oe in a range of temperatures from 1.65 to 4.2°K. The highest polarization was reached on protons in polycaprolactam of type II in a field of 19,200 Oe (ν_e = 53.5 GHz) at a temperature of 2.1°K. Further, the dependence of the polarization on the microwave power and nuclear relaxation times were measured. The temperature dependence of the distance between positive and negative polarization maxima was observed. (auth)

3602 SCATTERING OF ^{3}He BY ^{4}He AND OF ^{4}He BY TRITIUM. Spiger, R. J.; Tombrello, T. A. (California Inst. of Tech., Pasadena). Phys. Rev., 163: 964-84(Nov. 20, 1967).

The differential elastic scattering cross section was measured for the scattering of ^{3}He from ^{4}He and the scattering of ^{4}He from tritium for bombarding energies of 5 to 18 and 4 to 18 MeV, respectively. Data were also obtained for the reactions ^{4}He(^{3}He,p)^{6}Li, ^{4}He(^{3}He,p')^{6*}Li, ^{3}H(α,n)^{6}Li, and ^{3}H(α,n')^{6*}Li. Levels are seen at 4.65, 6.64, 7.47, and 9.7 MeV in ^{7}Li, and at 4.57, 6.73, 7.21, and 9.3 MeV in ^{7}Be. A phase-shift analysis suggests assignments of $\frac{7}{2}^-$ and $\frac{5}{2}^-$ for the two lower levels in ^{7}Li, confirms the $\frac{5}{2}^-$ assignment of the 7.47 level, and suggests a $\frac{7}{2}^-$ assignment for the new level at 9.7 MeV. Similarly in ^{7}Be, the assignments of $\frac{7}{2}^-$ and $\frac{5}{2}^-$ for the lower two levels are confirmed, and an assignment of $\frac{7}{2}^-$ is suggested for the new level at 9.3 MeV. The reduced widths for α and nucleon emission were determined by fitting the phase shifts near each level with a single- and/or double-level formula from the R-matrix formalism of Lane and Thomas. The results of the analysis are discussed and are compared with predictions of recent nuclear-model calculations. (auth)

3603 WHAT NEEDS EXPLAINING IN THE PHOTODISINTEGRATION OF ^{3}He? Barton, G. (Univ. of Sussex, Eng.). Nucl. Phys., A104: 289-93(1967).

The photodisintegration of ^{3}He is discussed in the light of the non-relativistic version of the Cabibbo–Radicati sum rule, which amounts to a new decomposition of the standard bremsstrahlung-weighted electric dipole sum rule according to the isobaric spin, $I = \frac{1}{2}$ or $I = \frac{3}{2}$, of the final state. Experiment shows that, most remarkably, the sum rule for $I = \frac{1}{2}$ is exhausted by the two-body breakup into d + p, to the practical exclusion of three-body states with $I = \frac{1}{2}$. Some implications of the sum rules are pointed out for attempts to calculate the disintegration cross section. (auth)

3604 ANALYSIS OF THE p-^{3}He LOW-ENERGY INTERACTION. Drigo, L.; Pisent, G. (Univ., Padua). Nuovo Cim. (10), 51B: 419-36(Oct. 11, 1967).

The elastic scattering of protons from ^{3}He nuclei at the very low energies is analyzed. A phase-shift analysis on the cross-section and polarization data leads to the determination of four solution sets. These mathematical solutions are examined in the light of a nucleon–nucleus potential model. The structure of the spin-dependent interaction which is necessary to assume in order to reproduce the experiments is widely discussed. Some elements on the discrimination between phase-shift ambiguities are also given by the potential calculation, but for a clear-cut conclusion on this point, further high-energy analyses, and perhaps triple-scattering experiments will be probably needed. (auth)

Nuclear Properties and Reactions, 6 ≤ A ≤ 19

Refer also to abstracts 3256, 3465, 3487, 3600, 3602, 3641, 3694, 3743, 3748, 3755, and 3762.

3605 (CEA-R-3270) ANALYSE BIPARAMETRIQUE DES REACTIONS A TROIS CORPS ^{11}B(p,$\alpha\alpha$) DE 163 keV A 2 MeV. (Two-Dimensional Analysis of Three-Body Reactions ^{11}B(p,$\alpha\alpha$) From 163 keV to 2 MeV). Engelhardt, Dieter; Fontenille, Jean (Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires). July 1967. 19p. (In French). Dep.

An experimental apparatus for two-dimensional analysis of the breakup of ^{12}C* produced by the reaction ^{11}B(p,$\alpha\alpha$)^{4}He at proton bombarding energies between 163 keV and 2 MeV is described. It uses Si surface-barrier detectors and fast-slow coincidence techniques: the energy resolution is about 40 keV and the time resolution is 6 nsec. A 4096-channel analyzer and a small digital computer was used for information storage and data processing. The experimental setup was tested on the CENG 2-MeV Van de Graaff accelerator. The spectra of the ^{12}C* decay products taken at proton bombarding energies of 163 and 680 keV at different angles between the two α counters are shown. They indicate strong evidence for sequential decay of ^{12}C* to the ^{8}Be fundamental, first, or second excited level. (auth)

3606 (IFA-CRD-35) ANGULAR CORRELATION MEASUREMENTS IN THE ^{11}B(p,n'γ)^{11}C REACTION FOR E_p = 7.8 MeV. Calboreanu, A.; Molea, M.; Salagean, O.; Ciocanel, A.; Minzatu, I. (Academia R. P. R., Bucharest. Institutul de Fizica Atomica). July 1967. 8p. Dep.

An experimental arrangement for measuring the ^{11}B(p,n'γ)^{11}C reaction angular correlations is described. Some conclusions are also drawn concerning the reaction mechanism for this nuclear process. (auth)

3607 (ORNL-TM-1872) EVALUATION OF NEUTRON CROSS SECTIONS FOR ^{10}B. Irving, D. C. (Oak Ridge National Lab., Tenn.). Oct. 9, 1967. Contract W-7405-eng-26. 45p. Dep. CFSTI.

The neutron cross sections for ^{10}B were evaluated from 10^{-4} eV to 15 MeV. The existing experimental data are reviewed, and theoretical calculations and other reasoning are used to fill in the gaps. A complete and consistent set of cross sections is presented, and an explanation is given for the choices made in developing this cross-section set. (auth)

3608 (PUC-937-165) EVEN PARITY STATES OF ^{16}O AND ^{17}O. Brown, G. E. (Princeton Univ., N. J. Palmer Physical Lab.); Green, A. M. (Institute for Advanced Study, Princeton, N. J.). June 1965. 36p. Dep. CFSTI.

A model in which there are low-lying deformed states in addition to the usual shell-model states is outlined. The nuclei ^{16}O and ^{17}O are discussed in some detail within the content of the model; the nucleus ^{18}O is also considered briefly. (D.C.W.)

3609 (PUC-937-164) INELASTIC PROTON SCATTERING IN THE 2sld SHELL. Crawley, Gerard M. (Princeton Univ., N. J. Palmer Physical Lab.). June 1965. Contract AT(30-1)-937. 136p. Dep. CFSTI.

Thesis.

The inelastic scattering of 17.5-MeV protons from a number of nuclei in the 2sld shell was studied using lithium-drifted silicon detectors. The target nuclei were ^{16}O, ^{19}F, ^{24}Mg, ^{25}Mg, ^{26}Mg, ^{27}Al, ^{28}Si, ^{31}P, and ^{32}S. Four detectors were used simultaneously to increase the efficiency of taking data. The proton beam from the Princeton frequency modulated cyclotron had an energy resolution 30 keV, and the total resolution of the system was typically about 50 keV. Extensive use was made of both the IBM 1620 and IBM 7094 computers in analyzing the data. Angular distributions were obtained for up to twenty energy levels in each nucleus. While many of these distributions were quite similar, there were a number of cases in even-A, even-Z nuclei where states with the same spin and parity had very different angular distributions. The angular distributions from the strongest levels were compared with the predictions of the distorted wave Born approximation. Good agreement was obtained for the first 2^+ states in ^{24}Mg, ^{28}Si, and ^{32}S and for many of the strong levels in ^{19}F, ^{27}Al, and ^{31}P. Reasonable fits were also obtained for a number of 3^- states. The value of the transition strengths extracted from the comparison of the DWBA predictions with the data in general agreed reasonably well with the values from electromagnetic measurements. One notable exception was the value of the transition strength for the 1.35 MeV ($\frac{5}{2}^-$) level in ^{19}F which was a factor of three lower than the value extracted from a Coulomb excitation experiment. The relative cross sections determined in this experiment were also compared with the predictions of various nuclear models. The results for ^{23}Na and ^{25}Mg agreed quite well with a strong coupling nuclear model while ^{27}Al and ^{31}P were better explained by a weak coupling model. A number of previously unreported levels were observed in ^{23}Na (5.38 MeV, 5.75 MeV, and 5.94 MeV), ^{27}Al (7.23 MeV, 7.44 MeV, 7.66 MeV, 7.79 MeV, and 7.99 MeV), ^{31}P (5.34 MeV and 5.67 MeV), and ^{32}S (5.41 MeV, 6.41 MeV, and 6.76 MeV). (auth)

3610 LOWEST TWO $T = \frac{3}{2}$ STATES OF ^{17}F OBSERVED IN THE ^{16}O(p,p)^{16}O REACTION. Patterson, J. R.; Winkler, H.; Zaidins, C. S. (California Inst. of Tech., Pasadena). Phys. Rev., 163: 1051-5(Nov. 20, 1967).

The lowest $T = \frac{3}{2}$ state of ^{17}F was observed in the isospin-forbidden ^{16}O(p,p)^{16}O reaction, where anomalies were found in the elastic channel and in the inelastic channels to the 6.13- and 7-12-Mev states of ^{16}O. The partial width Γp_0 of this state as obtained from a phase-shift analysis of the elastic data is Γp_0 = 40 eV. The excitation energies of both the lowest and the next higher $T = \frac{3}{2}$ states were determined by using the ^{12}C(α,n)^{15}O threshold and a ^{24}Mg(α,γ)^{28}Si resonance as calibration points.

Values of E_x = 11.202 ± 0.008 MeV (E_p = 11.276 ± 0.008 MeV) and 12.554 ± 0.008 MeV (E_p = 12.714 ± 0.008 MeV) were obtained, in agreement with the positions determined for the $^{15}N(^3He,n)^{17}F$ reaction. The second T = $\frac{3}{2}$ state is well suited as an energy calibration point for accelerators. (auth)

3611 POLARIZATION OF NEUTRONS FROM THE $^{14}N(d,n)^{15}O$(g.s.) REACTION. Meier, M. M.; Purser, F. O. Jr.; Walter, R. L. (Duke Univ., Durham, N. C.). Phys. Rev., 163: 1056-9 (Nov. 20, 1967).

Four angular distributions of the polarization of the neutrons produced in the $^{14}N(d,n)^{15}O$(g.s.) reaction were measured for deuteron energies from 3.1 to 3.7 MeV. The polarization is generally negative for angles less than 70° c.m. and positive for larger angles. These features and other similarities were observed in a few deuteron-induced stripping reactions which proceed via orbital momentum transfers of one unit. The significance of this observation is discussed. (auth)

3612 BRANCHING-RATIO MEASUREMENTS ON THE 6.92- AND 7.12-MeV STATES IN ^{16}O. Lowe, J. (Birmingham Univ., Eng. Brookhaven National Lab., Upton, N. Y.); Alburger, D. E.; Wilkinson, D. H. Phys. Rev., 163: 1060-5(Nov. 20, 1967). (BNL-11492).

Measurements were made on the branching ratios for cascade decay of the 2^+ 6.92- and the 1^- 7.12-MeV states of ^{16}O through the 0^+ 6.06-MeV state. For the 6.92-MeV state, the result, $2.9 \pm 0.4 \times 10^{-4}$, is consistent with earlier results. For the 7.12-MeV state, an upper limit of $< 6 \times 10^{-6}$ is set on the cascade branch which corresponds to a strongly inhibited E1 transition. The significance of this latter result for the structure of the 6.06-MeV state is discussed. (auth)

3613 SPIN ASSIGNMENT FOR THE ^{18}F 1.131-MeV LEVEL. Warburton, E. K. (Brookhaven National Lab., Upton, N. Y.). Phys. Rev., 163: 1032-4(Nov. 20, 1967). (BNL-11529).

Recent γ-ray angular-distribution results obtained by Poletti and Fossan using the differential-time-delay technique in the $^{16}O(^3He,p\gamma)^{18}F$ reaction are analyzed to show that the ^{18}F 1.131-MeV level has J = 5. Other evidence fixes its parity as even. (auth)

3614 DETERMINATION AND DISTORTED-WAVE BORN APPROXIMATION ANALYSIS OF THE NEUTRON POLARIZATION IN THE $^{12}C(^3He,n)^{14}O$ REACTION. Schaller, L. A. (Duke Univ., Durham, N. C.); Thomason, R. S.; Roberson, N. R.; Walter, R. L.; Drisko, R. M. Phys. Rev., 163: 1034-43(Nov. 20, 1967).

Nine angular distributions of the neutron polarization produced in the $^{12}C(^3He,n)^{14}O$ (ground-state) reaction were determined for ^3He energies from 2.24 to 3.70 MeV. High polarizations were found at all energies, the extreme values being −0.87 at 2.39 MeV and 50°, and +0.72 at 3.70 MeV and 40°. Below 3.2 MeV, the neutron yield at 0° and the differential cross sections exhibit compound-nuclear effects. Above this energy, the 0° yield curve is structureless, and the cross section shows pronounced l = 0, diproton stripping patterns. Also, the three polarization distributions between 3.30 and 3.70 MeV are similar. An attempt was made to fit the 3.70-MeV ($^3He,n$) cross section and neutron polarization distributions with a distorted-wave Born-approximation (DWBA) analysis. Prior to this analysis, ^3He elastic-scattering data were obtained over the region from 3.6 to 3.8 MeV, and optical-model parameters for the incident channel were extracted. Considering the possible compound-nuclear effects which were neglected in the fitting procedure, reasonable results were achieved with the DWBA code. One striking result was that the predicted polarization is insensitive to the ^3He spin-orbit strength. (auth)

3615 INELASTIC SCATTERING OF ELECTRONS FROM THE 19.08-MeV LEVEL IN ^{16}O. Drake, T. E.; Hutcheon, R. M.; Stobie, V. W.; Beer, G. A.; Caplan, H. S. (Saskatchewan Accelerator Lab., Saskatoon). Phys. Rev., 163: 947-9(Nov. 20, 1967).

The form factor for the 19.08-MeV level in ^{16}O was measured for momentum transfers between 60 and 260 MeV/c. The results, when compared with particle-hole calculations, strongly support an assignment J = 2. Since the transition is transverse, the parity is negative; and the assignment to the level is $J^\pi = 2^-$. (auth)

3616 SHELL-MODEL THEORY OF NUCLEAR REACTIONS IN DEFORMED NUCLEI. Afnan, Iraj R. (Massachusetts Inst. of Tech., Cambridge). Contract AT(30-1)-2098. Phys. Rev., 163: 1016-29(Nov. 20, 1967). (MIT-2098-317).

A theoretical study was made of the intermediate-structure resonances observed in neutron scattering and proton capture by ^{19}F in terms of simple excitations of the compound nucleus using Feshbach's formalism for nuclear and photonuclear reactions. The simple excitations were taken to be particle-hole states in the deformed-level scheme, including the excitation of rotational bands. The average resonance widths, and spacing, and average total cross section (ΔE = 0.5 MeV) observed for n + ^{19}F with neutron energy between 0.5 and 2.5 MeV is reasonably well reproduced by the model. In particular, the agreement with the average total cross section indicates that an optical potential can be derived from the above model. In proton capture by ^{19}F, though the calculated widths of the resonances are of the correct order of magnitude, the relative spacing of the resonances and magnitude of the cross sections is not in agreement with experiment. (auth)

3617 ROTATIONAL LEVEL STRUCTURE IN ^{16}O. Goldhammer, Paul; Prosser, F. W. Jr. (Univ. of Kansas, Lawrence). Contract AT(11-1)-1120. Phys. Rev., 163: 950(Nov. 20, 1967). (COO-1120-63).

A recent determination of the branching ratio (6.92 → 6.05)/(6.92 → 0) in ^{16}O has previously been used to demonstrate that the ground state retains approximately an 11% deformed character. By assuming that the $J^\pi = 2+$ and 4+ levels at 6.92 and 10.36 MeV adhere strictly to a rotational relation, an independent estimate of this admixture is obtained. Agreement is found to be excellent. (auth)

3618 THRESHOLD PHOTONEUTRON CROSS SECTION FOR ^9Be. Berman, B. L.; Van Hemert, R. L.; Bowman, C. D. (Univ. of California, Livermore). Contract W-7405-eng-48. Phys. Rev., 163: 958-63(Nov. 20, 1967). (UCRL-70331).

The $^9Be(\gamma,n)^8Be$ cross section was measured as a function of photon energy from less than 1 to about 40 keV threshold, by the threshold photoneutron technique. The cross section rises sharply to a maximum of 1.6 mb at 6 keV above threshold and then decreases slowly to 1.2 mb at 40 keV. An attempt was made to fit these data, and earlier data obtained from monoenergetic γ-ray source measurements, with a curve of the Breit–Wigner form in order to examine the possibility that the shape of the cross section is influenced premarily by a single level near threshold. The results show that such a curve is inadequate to explain the data, and thus indicate that a more complex theory and even better data are needed to understand fully the nature of the cross section near threshold for the $^9Be(\gamma,n)$ reaction. (auth)

3619 THE ANALYSIS OF THE $^7Li(p,\alpha)^4He$ REACTION IN THE 0.5- TO 7-MeV ENERGY RANGE. Borsaru, M.; Cenja, M.; Hategan, C.; Iliescu, E. (Inst. of Atomic Physics, Bucharest). Rev. Roum. Phys., 12: 661-7(1967).

An analysis of experimental data including the total cross section, angular distributions and the sensitivity towards incident proton polarization r (θ) of the $^7Li(p,\alpha)\alpha$ reaction was performed in the energy range 0.5 to 7 MeV, using the R-matrix theory formalism. The reduced widths of three 2^+ levels in ^8Be nucleus were obtained, which explain the experimental data in a satisfactory way. (auth)

3620 ELASTIC NEUTRON SCATTERING ON ^{16}O. Hokim, Q. (Laval Univ., Quebec). Nuovo Cim. (10), 51B: 492-501(Oct. 11, 1967).

Neutron elastic scattering from a ^{16}O target was studied with Feshbach's formalsim of nuclear reactions. The compound states formed during the scattering process are simulated as a superposition of two-particle, one-hole excitations, constructed by the usual shell-model method. Antisymmetrization requirements are satisfied, and spurious states are properly eliminated. The structure of negative-parity states of angular momentum J = $\frac{1}{2}$, $\frac{3}{2}$, $\frac{5}{2}$ lying below the first inelastic threshold is examined; the positions and widths of the resonances are predicted and are compared with available experimental data. (auth)

3621 REACTION $^9Be(^6He,\alpha)^{11}Be$. Stepancic, B.; Popic, R.; Aleksic, M. (Institute of Nuclear Science "Boris Kidrich," Belgrade). Phys. Rev. Lett., 19: 1137-8(Nov. 6, 1967).

The reaction $^9Be(^6He,\alpha)^{11}Be$ was investigated using ^6He that was produced by the reaction $^9Be(n,\alpha)^6He$ in the irradiation of Be with 14-MeV neutrons. The activity of the ^{11}Be produced in the reaction was measured. Measurements were made of β activity alone, β activity in coincidence with γ activity, and γ activity in coincidence with β activity. An average value of 11 ± 4 mb was obtained for the reaction $^9Be(^6He,\alpha)^{11}Be$. (D.C.W.)

3622 EFFECTIVE INTERACTION AND THE REACTIONS $^7Li(p,p')^7Li$(478 keV) AND $^7Li(p,n)^7Be$(431 keV). Locard, P. J.; Austin, S. M.; Benenson, W. (Michigan State Univ., East Lansing). Phys. Rev. Lett., 19: 1141-4(Nov. 6, 1967).

The total cross sections for the reactions $^7Li(p,p')^7Li$(478 keV) and $^7Li(p,n)^7Be$(431 keV) were measured for proton energies between 23 and 52 MeV and were compared with the predictions of a microscopic model of the reaction. The spin-flip, isospin-flip part of the effective interaction is found to be essentially indepen-

dent of energy, whereas the pure central part appears to decrease with increasing energy. (auth)

3623 PHOTON SCATTERING BY THE GIANT MAGNETIC DIPOLE STATES IN ^{12}C, ^{24}Mg, AND ^{28}Si. Kuehne, H. W.; Axel, P.; Sutton, D. C. (Univ. of Illinois, Urbana). Contract N00014-67-A-0305-0005. Phys. Rev., 163: 1278-91(Nov. 20, 1967).

Photons, defined in energy to about 1% with the aid of a bremsstrahlung monochromator, were scattered by isolated energy levels in C, Mg, and Si. Parameters for the six observed were determined. The 15.11-MeV level in ^{12}C, the 9.92- and 10.66-MeV levels in ^{24}Mg, and the 11.42-MeV level in ^{28}Si are T = 1, $T_z = 0$ analogs of low-lying 1+ states in the neighboring odd-odd nuclei. These levels exhaust most of the magnetic dipole transition strength of the respective nuclei, and therefore give information about the expectation value of $1 \cdot s$ in the ground state. (TSN)

3624 ACTIVATION CROSS SECTIONS FOR THE $^{19}F(n,2n)^{18}F$, $^{23}Na(n,2n)^{22}Na$, $^{55}Mn(n,2n)^{54}Mn$, $^{115}In(n,2n)^{114m}In$, $^{165}Ho(n,2n)^{164m}Ho$, $^{115}In(n,n')^{115m}In$, AND $^{27}Al(n,\alpha)^{24}Na$ REACTIONS. Menlove, H. O. (Lockheed Research Lab., Palo Alto, Calif.); Coop, K. L.; Grench, H. A.; Sher, R. Phys. Rev., 163: 1308-14(Nov. 20, 1967).

The (n,2n) activation cross sections of ^{19}F, ^{23}Na, ^{55}Mn, ^{115}In, and ^{165}Ho were measured in the neutron energy range from 12.7 to 19.4 MeV. In addition, the activation cross sections for the ^{115}In $(n,n')^{115m}In$ and $^{27}Al(n,\alpha)^{24}Na$ reactions were measured in the energy range from 1.0 to 19.4 MeV and from 6.1 to 19.4 MeV, respectively. Most of the measurements were made relative to the fission cross section of ^{235}U. The experimental (n,2n) cross sections were compared with the predictions of the semiempirical cross-section theories of Pearlstein and of Gardner. (auth)

3625 YIELDS FROM PHOTONUCLEAR REACTIONS $^{12}C \rightarrow {}^{11}C$, $^{27}Al \rightarrow {}^{24}Na$, $^{28}Si \rightarrow {}^{24}Na$ FOR HIGH ENERGY PHOTONS. Antuf'ev, Yu. P.; Miroshnichenko, I. I.; Noga, V. I.; Sorokin, P. V. Yadern. Fiz., 6: 431-2(Aug. 1967). (In Russian).

The correlation between the cross section per equivalent γ quantum and the maximum energy of the bremsstrahlung was measured for 3 photonuclear reactions, $^{12}C \rightarrow {}^{11}C$, $^{27}Al \rightarrow {}^{24}Na$, and $^{28}Si \rightarrow {}^{24}Na$, by means of the induced activity method. The measurements were carried out on the electron accelerator of the Physical–Technical Institute of the Academy of Sciences, in the energy range from 100 to 1670 MeV, with high-purity materials. The targets were placed in the γ beam of the bremsstrahlung generated in a tantalum converter; the radioisotopes formed were identified by their half-lives and the energy of their γ quanta. The cross section, σ_Q, of the first reaction at energies up to 260 MeV agreed with the findings of W. C. Barber et al. The corresponding values of the other two reactions have been measured earlier by A. N. Gorbunov et al.; the new values also agreed with the previously reported data. It was noted that σ_Q decreases with the increasing number of nucleons emitted from the nucleus while the relative increase of σ_Q with energy increases with the number of the emitted nucleons. The results may be used for the calibration instruments intended for measuring high-energy bremsstrahlung fluxes. (TTT)

3626 HYPERNUCLEAR SPECTROSCOPY FOR A = 6. Ananthanarayanan, K. (Stanford Univ., Calif.). Contract AF49(638)-1389. (Phys. Rev., 163: 985-92(Nov. 20, 1967).

The hypernuclei $_{\Lambda\Lambda}{}^{6}He$ and $_{\Lambda}{}^{6}He$ are studied using the method of Dawson, Talmi, and Walecka. As a check on the calculation, ^{6}He is also studied using a pure central force for the neutron–neutron interaction. By working within a harmonic-oscillator framework, the Bethe–Goldstone equation is transformed to relative coordinates and is solved using the variational procedure developed by Dawson and Walecka. Assuming a pure central potential with a Yukawa shape for the Λ–Λ interaction, the strengths of the potential yielding the observed binding energy are found for three different ranges. As a check, the binding energy of ^{6}He is estimated assuming central potentials of the Bruckner–Gammel–Thaler type and of the Hamada type. The spin-orbit and tensor parts of the potentials are neglected, because the neutrons interact most strongly in a relative singlet s state. Too much binding is found, presumably because of our use of harmonic-oscillator single-particle potentials. A 15% reduction in the attractive part of the central Hamada-type potential gives reasonable binding for the neutrons. The energy levels of the ground state and excited states of $_{\Lambda}{}^{6}He$ are estimated using the potentials given by Shemsher Ali, Grypeos, and Kok. A 20 to 25% reduction in the potential yields the observed binding of the ground state. In addition to the ground state, which is 1^-, a 2^- excited state is also found, which may not be bound against breakup into $_{\Lambda}{}^{5}He$ + n. (auth)

3627 (^{7}Li,p), (^{7}Li,d), AND (^{7}Li,t) REACTIONS ON ^{12}C NEAR 3.5 MeV. Morgan, James F.; Hobbie, Russell K. (Univ. of Minnesota, Minneapolis). Phys. Rev., 163: 992-4(Nov. 20, 1967).

The reactions $^{12}C(^7Li, p_0)^{18}O$, $^{12}C(^7Li, p_1)^{18}O$, $^{12}C(^7Li, d_1)^{17}O$, and $^{12}C(^7Li, t_0)^{16}O$ were studied at laboratory energies of 3.3, 3.5, and 3.7 MeV. The reactions appear to proceed mainly through the compound nucleus. (auth)

3628 DEFORMED STATES IN ^{12}C. Soga, M. (Bartol Research Foundation, Swarthmore, Pa.). Contract AT(30-1)-3525. Phys. Rev., 163: 995-6(Nov. 20, 1967). (NYO-3525-17).

A calculation of energy levels in ^{12}C using projected Nilsson wave functions was performed, and the optimum deformation in each J state was found. The orthogonality between wave functions corresponding to different deformation was studied. (auth)

3629 NUCLEAR POLARIZATION IN THE $^{11}B(d,p)^{12}B$ REACTION. II. Pfeiffer, Loren; Madansky, L. (Johns Hopkins Univ., Baltimore). Phys. Rev., 163: 999-1003(Nov. 20, 1967).

Measurements were made of the polarization of the ^{12}B recoil nuclei resulting from the $^{11}B(d,p)^{12}B$ reaction for E_d in the range 0.90 to 3.20 MeV. The polarization is observed by measuring the β-decay asymmetries of the ^{12}B recoil nuclei with respect to the reaction plane. The ^{12}B recoil nuclei formed in the ground state are separated kinematically from those in excited states and are then stopped in various solids in the presence of a small magnetic field normal to the reaction plane. The sign of the observed polarization for all measurements is in the direction of the vector $k_d \times k_p$. The magnitude of the polarization is strongly dependent on E_d, the recoil emission angle and the material used to stop the recoils. It is found that the polarization of ^{12}B nuclei can be maintained in either metallic Pd or Au at room temperature, using holding fields smaller than 20 G. For recoils stopped in Pt metal, a magnetic field of about 200 G is required to maintain the nuclear polarization. The ^{12}B recoil polarization plotted as a function of E_d shows definite structure. Polarization resonances are observed at 1.5, 2.1 and 3.0 MeV. At these energies the measured relative polarizations are $+8.01 \pm 0.30$, $+4.29 \pm 0.30$, and $+3.86 \pm 0.27\%$, respectively, for a Pt metal recoil stopper and a 49° (lab) recoil angle. These resonances are tentatively identified with states of the ^{13}C compound nucleus near 20.0 MeV and at 20.52 and 21.28 MeV. It is believed that the polarization resonances may result from an interference between direct interaction and two-particle compound resonance processes. (auth)

3630 INELASTIC 1 GeV PROTON SCATTERING FROM CARBON AND OXYGEN. Friedes, J. L. (Brookhaven National Lab., Upton, N. Y.); Palevsky, H.; Sutter, R. J.; Bennett, G. W.; Igo, G. J.; Simpson, W. D.; Corley, D. M. Nucl. Phys., A104: 294-300(1967). (BNL-11371).

Results are presented for 1 GeV protons inelastically scattered from the low-lying levels in ^{12}C and ^{16}O. Using the Blair diffraction model, the deformation parameters are obtained, and are rather large when compared to those obtained for the same nuclei using 40 MeV alpha particles as incident projectiles. However, the deformation lengths are found to be quite consistent for all particles at all energies. (auth)

3631 STUDY BY COINCIDENCE MEASUREMENTS OF REACTIONS PRODUCING THREE BODIES: APPLICATION TO $^7Li + d \rightarrow 2\alpha + n$ AND $^{11}B + p \rightarrow 3\alpha$. Flamant, Y.; Chanut, Y.; Ballini, R. (Institut d'Etudes Nucleaires, Alger, Algiers). J. Phys. (Paris), 28: 622-32(Aug.-Sept. 1967). (In French).

The results of an investigation of the mechanism of the reaction $^7Li + d \rightarrow 2\alpha + n$ at 2 MeV and of the resonance in the reaction $^{11}B + p \rightarrow 3\alpha$ at 2.65 MeV are presented. (D.C.W.)

3632 THE REACTION $^{14}N(d,\alpha)^{12}C$ AT 28.5 MeV. Vidal, J. L.; Bouche, R.; Fayard, C.; Feuvrais, L.; Gaillard, M. Gaillard, P.; Gouanere, M.; Gusakow, M.; Lamot, G. H.; Pizzi, J. R. (Institut de Physique Nucleaire, Lyon). J. Phys. (Paris), 28: 617-21(Aug.-Sept. 196). (In French).

Differential cross sections for the $^{14}N(d,\alpha)^{12}C$ reaction induced by 28.5-MeV deuterons were studied from 10 to 90° in the laboratory system. By assuming a direct reaction mechanism, a distorted-wave Born approximation analysis was made, allowing one to compare theoretical and experimental cross-section distributions. (auth)

3633 ANGULAR DISTRIBUTIONS OF ALPHA PARTICLES FROM THE REACTION $^{16}O(n,\alpha)^{13}C$ AT E_n = 14.1 MeV. Hsu, Yuin-chi; Huang, Chia-yi; Chang, Ching-ching (National Taiwan Univ., China). Nucl. Phys., A104: 677-82(1967).

A cloud chamber was used to study the $^{16}O(n,\alpha)^{13}C$ reaction at E_n = 14.1 MeV. The angular distributions of the α-particle groups leading to $^{13}C^*$ = 0, 3.08 and 3.68 + 3.85 MeV, and especially the observed strong peaks at backward angles, suggest that the heavy-particle stripping process plays an important role in the $^{16}O(n,\alpha)$ ^{13}C reaction. Theoretical fits to the observed angular distributions in terms of the heavy-particle stripping process were attempted

for backward angles and in terms of the knock-on process for forward angles. (auth)

3634 LIFETIME OF THE LOWEST $5/2^+$ STATES IN ^{15}N AND ^{15}O. Bizzeti, P. G.; Bizzeti-Sona, A. M.; Kalbitzer, S.; Povh, B. (Max-Planck-Institut fuer Kernphysik, Heidelberg. Univ., Heidelberg). Nucl. Phys., A104: 577-87(1967).

The lifetime of the $J^\pi = 5/2^+$ mirror states at $E_x = 5.270$ and 5.240 MeV in ^{15}N and ^{15}O, respectively, were deduced from Doppler-shift measurements with a Ge(Li) detector. The two nuclei were produced by ^{14}N bombardment of D and ^9Be targets. The different stopping times of recoiling ions in Mg, Al, Cu, and Au were exploited to deduce the following lifetimes: $\tau = 2.9 \pm 0.5$ ps for the state in ^{15}N and $\tau = 3.2 \pm 0.5$ ps for the state in ^{15}O. Recoil-distance measurements have also been performed; the results are similar, though less accurate. The measured lifetimes give information on the structure of the two mirror states. (auth)

3635 INELASTIC SCATTERING OF ^3He FROM ^6Li, ^7Li, ^{10}B, ^{19}F, AND ^{27}Al AT 10 MeV. Coop, K. L.; Poate, J. M.; Titterton, E. W. (Australian National Univ., Canberra). Aust. J. Phys., 20: 609-11(Oct. 1967).

The differential cross sections for the inelastic scattering of 10-MeV ^3He ions by ^{27}Al, ^{19}F, ^6Li, and ^7Li at 40° and by ^{10}B at 40, 90, and 140° were measured using semiconductor detectors in the focal planes of either a Buechner mass spectrograph or a 24-in. double-focusing spectrometer to identify the particle groups. (D.C.W.)

3636 STUDY OF ^3He RADIATIVE CAPTURE REACTIONS. Puttaswamy, Nuggehalli Gujjegowda. Stanford, Calif., Stanford Univ., 1966. 131p.

Thesis.

Four ^3He radiative capture reactions were studied using a ^3He beam from a 3-MeV Van de Graaff accelerator. The gamma rays produced by ^3He bombardment of ^{13}C, ^{12}C, ^{11}B, ^{10}B are detected by a 5 in. × 6 in. NaI(Tl) crystal surrounded by a plastic anticoincidence shield. Pulse-pileup rejection is accomplished by the use of a tunnel-diode discriminator. The differential cross sections for ^3He capture gamma rays are found to be typically 0.1 μb/sr. ^3He capture by ^{13}C was investigated for ^3He energies from 1 to 3.5 MeV. Excitation curves for the gamma-ray transition to the ground state in ^{16}O were measured at 90 and 0° to the beam axis. Two resonances are observed corresponding to excitation energies in ^{16}O of 24.05 and 25.12 MeV. However, the prominent resonance at 24.3 MeV observed in other capture (and photodisintegration) work and believed to be a component of the giant-dipole resonance is not evident in the ^3He capture work. A reasonable interpretation of the present results indicates that the giant-dipole states (i.e., particle-hole states) are not excited strongly in the ^3He capture reaction. Excitation curves for the 15.11- and 12.71-MeV gamma rays from the $^{13}C(^3He,\alpha\gamma)^{12}C$ reaction were measured for ^3He energies from 1 to 3 MeV. These curves exhibit a resonance at about 24.5 MeV (^{16}O excitation energy) for the 15.11-MeV gamma ray and at 23.95 and possibly also at 24.7 MeV for the 12.71-MeV gamma ray. Comparison of the present work with that of other ^3He-induced reactions in ^{13}C leads to the possible spin-parity assignments of 1^-, 2^+ (3^-) for the states at 24, 24.3, 24.7, and 25.1 MeV. The possibility of isospin mixing in the levels of ^{16}O was also considered. ^3He capture by ^{11}B was studied (at 90° to the beam axis) for ^3He energies from 1 to 3 MeV. Excitation curves for the gamma-ray transition to the ground state as well as to higher excited states in ^{14}N were measured. These excitation curves do not show any resonant structure. In the case of ^3He capture by ^{10}B and ^{12}C, the cross section for the gamma-ray transition to the ground state (in the compound system) is found to be small and hence measurements are done only at two selected ^3He energies. Finally, various types of reaction mechanisms were considered for possible explanation of the resonant and nonresonant behavior of the excitation curves obtained from these ^3He capture reactions. (Disser. Abstr.)

3637 NUCLEON TRANSFER IN $^{14}N + ^{10}B$ AND $^{14}N + ^{40}Ca$. Couch, Jack Gary. College Station, Tex., Texas A and M Univ., 1966. 129p.

Thesis.

Thin targets of ^{10}B and ^{40}Ca were bombarded with ^{14}N ions accelerated in the Oak Ridge Tandem Van de Graaff. Range, energy, and angular distributions were obtained by measuring the activities of the positron emitters, ^{13}N and ^{11}C, formed in the neutron and proton transfer reactions. The $^{10}B(^{14}N, ^{13}N)^{11}B$ reaction was shown to involve primarily ground states of ^{11}B at 16.3 MeV (lab), and the angular distributions of ^{13}N showed nuclear absorption effects at energies as low as 10.8 MeV (lab). In the $^{10}B(^{14}N, ^{11}C)^{13}C$ reaction, the protons transfer to both the ground state and first excited state of ^{13}C, but no transfers involving the first excited state of ^{11}C were observed. The ^{11}C from the observed states yielded two peaks in the angular distributions. In the $^{40}Ca(^{14}N, ^{13}N)^{41}Ca$ reaction, excited states as well as ground states of ^{41}Ca are involved. The states could not be separated, however, because of limitations in energy resolution. The angular distributions were found to be relatively insensitive to the angular momentum transferred, as indicated by the good agreement between the data and the tunneling theory. Comparison of the tunneling theory to the total cross section data, however, showed strong disagreement. This discrepancy between theory and data is probably due to the large numbers of excited state transfers occurring in the reaction, particularly at high energies. (Disser. Abstr.)

3638 EXCITATION OF THE GIANT RESONANCES WITH MUONS AND ELECTRONS, AND NUCLEON EMISSION IN ELECTRON SCATTERING. de Forest, Taber Jr. Stanford, Calif., Stanford Univ., 1966. 150p.

Thesis.

Several ways in which nuclear structure can be investigated in muon capture and electron scattering experiments were investigated. Excitation of the giant resonance is discussed. If the nucleon–nucleon interaction were independent of spin and isospin, the giant resonance for a closed shell nucleus would be a supermultiplet consisting of $J^\pi = 0^-$, 1^-, and 2^-, T = 0 and 1 states. Although only the 1^-, T = 1 states are important in photonuclear experiments, all the T = 1 states contribute strongly in muon capture, and the 2^-, T = 1 states are expected to be important for electron scattering at large momentum transfers. These processes were investigated in ^{12}C and ^{16}O using the particle-hole model of the nucleus. A spin dependent internucleon potential which fits low-energy nucleon–nucleon scattering was used. The model itself also contains some spin dependence since the configuration energies are taken from the empirical level structures of the neighboring A ± 1 nuclei which are split by the spin-orbit interaction. If the nucleon–nucleon interaction were independent of spin and isospin, the nuclear matrix elements required to calculate the total muon capture rate would be equal: $M_V^2 = M_A^2 = M_P^2$. This assumption was used in several calculations. The most important contribution to the capture rate comes from the T = 1 states mentioned above. This equality was checked for capture to these states using the particle-hole model and it was found to be valid to 3% for ^{12}C and 10% for ^{16}O. At the same time the assumption that the ratio of the retarded to unretarded matrix elements is given by the elastic form factor was investigated. This was found to be good to 1% in all cases. The wave functions of the 2^-, T = 1 states were also used to calculate the cross section for electron scattering to these states. For both ^{12}C and ^{16}O the strength was found to concentrate in one state which is called a "giant magnetic quadrupole oscillation." Corresponding states which had the predicted momentum dependence were observed in electron scattering experiments. Electron scattering at large energy transfers was investigated and, in particular, it was considered what information can be obtained from coincidence experiments in which emitted nucleons are detected in addition to the electron. It is shown that the general form of the double coincidence cross section can be written as a linear combination of four generalized form factors which can be separated experimentally. The basic ideas involved in using double coincidence experiments to obtain information about single-particle binding energies and wave functions are reviewed. If nucleon interactions are neglected only one nucleon can be emitted (in Born approximation). Therefore two nucleon emission processes provide a method for investigating nucleon interactions within the nucleus. Due to the kinematic restrictions on one nucleon emission, there is a large region where only two or more nucleon emission processes will contribute in a double coincidence experiment. As an estimate of the type of results that would be obtained from such an experiment, the Coulomb part of the double coincidence cross section for electron scattering from a hard sphere Fermi gas was calculated. The results indicate that such experiments will be feasible with the new superconducting accelerators. (Disser. Abstr.)

Nuclear Properties and Reactions, $20 \leq A \leq 89$

Refer also to abstracts 3256, 3502, 3609, 3623–3625, 3635, 3637, 3694, 3740, 3743, 3755, and 3784.

3639 (BMwF-FBK-67-75) KERNSTRUKTURUNTERSUCHUNGEN MIT (t,α)-REAKTIONEN. (Nuclear Structure Studies by (t,α) Reactions). Bachner, D. (Bonn Univ. (West Germany). Institut fuer Strahlen and Kernphysik). June 1, 1967. 44p. (In German). Dep.

The reactions $^{64}Zn(t,\alpha)^{63}Cu$, $^{66}Zn(t,\alpha)^{65}Cu$ and $^{50}Cr(t,\alpha)^{49}V$ were

measured at an incident energy of 13 MeV; in addition, the reaction $^{48}Ti(^{3}He,d)^{49}V$ was studied at an incident energy of 18 MeV. Excitation energies are given for the resolved levels and angular momenta; and spectroscopic factors, extracted from the DWBA analysis of the angular distribution, were determined. The ground-state configurations of the target nuclei and the level structure of the final nuclei are discussed; some evidence was found for collective excitation in the (t,α) reaction. (auth)

3640 (BNL–50060) CROSS SECTION EVALUATION CENTER. EVALUATION OF THE NEUTRON CROSS SECTION OF MANGANESE FOR THE ENDF/B LIBRARY. Stephenson, T.; Prince, A.; Pearlstein, S. (Brookhaven National Lab., Upton, N. Y.). June 1967. 54p. Dep. CFSTI.

The evaluation of ^{55}Mn data for inclusion in the ENDF/B library is outlined, and a complete listing of the data in the ENDF/B format is presented. (D.C.W.)

3641 (BNWL-SA-639) HELIUM PRODUCTION BY (n,α) REACTIONS IN STAINLESS STEEL. DePino, A. Jr. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). June 3, 1966. Contract AT(45-1)-1830. 3p. Dep. CFSTI.

The rate of helium production in type-304 stainless steel in fast and thermal reactors was calculated. It was found that estimates of the total helium produced can be in error by as much as a factor of ten, due principally to uncertainties in the (n,α) cross sections, and that the boron and nitrogen reactions are more important in fast reactors than has been generally accepted. (D.C.W.)

3642 (CEA-R-3078) SUR LA SEPARATION DES MECANISMES DE REACTION A BASSE ENERGIE. ETUDE DES REACTIONS: $^{27}Al(d,p)^{28}Al$, $^{24}Mg(d,p)^{25}Mg$ ET $^{24}Mg(d,\alpha)^{22}Na$. (Separation of Reaction Mechanisms at Low Energy. Study of the Reactions: $^{27}Al(d,p)^{28}Al$, $^{24}Mg(d,p)^{25}Mg$, and $^{24}Mg(d,\alpha)^{22}Na$). Mermaz, Michel (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). June 28, 1966. 112p. (In French). Dep.

Thesis. Submitted to Univ. of Paris, France.

The two sets of angular distributions of (d,p) reactions on Al and Mg, measured between 2 and 6 MeV, have given the possibility of testing, in analyzing the statistical fluctuations of cross sections, the validity of the separation of their mean values into two parts: a direct part and another part given by the statistical mechanism. With the same method of analysis, excitation functions for several alpha groups of the reaction $^{24}Mg(d,\alpha)^{22}Na$ were studied, and evidence was obtained for an intermediate structure for the alpha channel leading to the third excited state of ^{22}Na. The angular distribution of the wide resonance at 15.9 MeV in ^{28}Al was obtained. (auth)

3643 (CEA-R-3142) ETUDE DES ETATS A CARACTERE COLLECTIF DES NOYAUX AU VOISINAGE DES COUCHES FERMEES PAR DIFFUSION INELASTIQUE DES PARTICULES α. (Study by α-Particle Scattering, of the Collective States of Closed Shell Nuclei with 28 Neutrons, 28 and 50 Protons). Bruge, Gaston (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Jan. 27, 1967. 90p. (In French). Dep.

Thesis. Submitted to Univ. of Paris, Orsay, France.

The results of a systematic study, by the inelastic scattering of 44-MeV alpha particles, of the collective states of nuclei near the closed shells with 28 neutrons and 28 and 50 protons are presented. The energy range corresponding to the two-phonon vibrational triplet was studied in detail. The nuclei considered were ^{52}Cr, ^{54}Fe, ^{56}Fe, ^{58}Fe, ^{58}Ni, ^{60}Ni, ^{62}Ni, ^{64}Ni, ^{112}Sn, ^{114}Sn, ^{116}Sn, ^{118}Sn, ^{120}Sn, ^{122}Sn, ^{124}Sn, ^{46}Ti, ^{48}Ti, and ^{50}Ti. The theoretical analysis was made with the Austern and Blair model using a phase-shift analysis of the elastic scattering. The deformation lengths and transition probabilities obtained are compared with other experimental and theoretical data. (D.C.W.)

3644 (IFA-NR-25) GAMMA–GAMMA DIRECTIONAL CORRELATION IN THE $^{35}Cl(n,\gamma)^{36}Cl$ REACTION. Cojocaru, V.; Patrutescu, M.; Petrascu, M.; Salagean, Maricara (Academia R. P. R., Bucharest. Institutul de Fizica Atomica). 1967. 20p. Dep.

Directional correlations of gamma–gamma cascades in the $^{35}Cl(n,\gamma)^{36}Cl$ reaction having a sum-energy of 8.57, 2.47, 1.95 and 1.68 MeV are measured with a sum-coincidence spectrometer. The results show that the most probable values for the energy level spins are J(0.788) = 2, J(1.949) = 2 or 3, and J(2.467) = 3. Likewise, the multipolarities of some gamma rays belonging to these cascades are established. (auth)

3645 (INP-558/PL) TOTAL REACTION CROSS-SECTION AND ELASTIC SCATTERING OF 24.7 MeV ALPHA PARTICLES IN THE REGION OF A = 60 NUCLEI. Budzanowski, A.; Grotowski, K.; Kuzminski, J.; Niewodniczanski, H.; Strzalkowski, A.; Sykutowski, S.; Szmider, J.; Wolski, R. (Institute of Nuclear Physics, Krakow (Poland)). 1967. 27p. Dep.

The total reaction cross section for the interaction of alpha particles of the energy of 24.7 MeV with Cr, Fe, Ni, Co, Cu, and Zn nuclei was measured by means of the transmission method. The corrections to the transmission measurements for the elastic scattering and for the charged products of reactions were determined from a specially performed experiment. The results for the total reaction cross-sections are in agreement with the optical model calculations. No minimum in the σ_R versus A curve for the nickel atomic mass numbers is observed. (auth)

3646 (ORNL–4182) ELASTIC AND INELASTIC SCATTERING OF 11.0-MeV PROTONS FROM ^{48}Ti, ^{51}V, ^{52}Cr, ^{54}Fe, ^{56}Fe, ^{59}Co, ^{60}Ni, ^{62}Ni, ^{64}Ni, ^{63}Cu, ^{65}Cu, ^{64}Zn, ^{66}Zn, AND ^{68}Zn: TABULATED DIFFERENTIAL CROSS SECTIONS. Dickens, J. K.; Perey, F. G.; Silva, R. J. (Oak Ridge National Lab., Tenn.). Nov. 1967. Contract W-7405-eng-26. 117p. Dep. CFSTI.

Numerical values of differential cross sections for elastic and inelastic scattering of 11.0-MeV protons from ^{48}Ti, ^{51}V, ^{52}Cr, ^{54}Fe, ^{56}Fe, ^{59}Co, ^{60}Ni, ^{62}Ni, ^{64}Ni, ^{63}Cu, ^{65}Cu, ^{64}Zn, ^{66}Zn, and ^{68}Zn are reported in tabular form. Cross sections were determined at 5° intervals between laboratory angles of 20 and 164°. Inelastic scattering data are reported for 8 excited states of ^{48}Ti, 7 excited states of ^{51}V, 21 excited states of ^{52}Cr, 9 excited states of ^{54}Fe, 9 excited states of ^{56}Fe, 9 excited states of ^{59}Co, 13 excited states of ^{60}Ni, 10 excited states of ^{62}No, 9 excited states of ^{64}Ni, 10 excited states of ^{63}Cu, 5 excited states of ^{65}Cu, 5 excited states of ^{64}Zn, 6 excited states of ^{66}Zn, and 6 excited states of ^{68}Zn. (auth)

3647 (PUC–937-168) HOLE STATES OF ^{43}Ca AND ^{47}Ca. Conlon, T. W.; Bayman, B. F.; Kashy, E. (Princeton Univ., N. J. Palmer Physical Lab.). Mar. 28, 1965. 20p. Dep. CFSTI.

Levels in ^{43}Ca and ^{47}Ca which can be interpreted as neutron hole states in the $1d_{\frac{3}{2}}$ and $2s_{\frac{1}{2}}$ shells were observed through the (p,d) reaction. For ^{43}Ca, the $1d_{\frac{3}{2}}$ hole state ($T = \frac{3}{2}$) lies at 0.993 MeV, while for ^{47}Ca, the indications are that the $2s_{\frac{1}{2}}$ and the $1d_{\frac{3}{2}}$ levels lie very close to 2.60 MeV. Small amounts of p-wave admixtures are found in ^{44}Ca and to a much smaller degree in ^{48}Ca. (auth)

3648 RADIATIVE CAPTURE OF FAST NEUTRONS BY THE ^{37}Cl, ^{87}Rb, AND ^{193}Ir ISOTOPES. Dovbenko, A. G.; Kolesov, V. E.; Koroleva, V. P.; Tolstikov, V. A. At. Energ. (USSR), 23: 151-3(1967). (In Russian).

The relative activation method was used to measure the radiative neutron capture cross section of ^{37}Cl and ^{87}Rb in the 0.15 to 1.4-MeV range, and of ^{193}Ir within the 0.15 to 3.2 MeV range, using the authors' previously described method and referring to the known thermal neutron capture cross-section values of these isotopes. It was found that at neutron energies of $E_n > 1$ MeV, the theoretical curve of ^{87}Rb lies above the experimental curve; this may be due to the important role played by the radiation width reduction mechanism caused by the emission of a neutron, whenever the excitation energy during multiple transition stayed above the bond energy. This process was not taken into account in the calculations. In the case of ^{37}Cl, the experimental and theoretical curves agreed up to $E_n \approx 0.3$ MeV; beyond this value the theoretical curve was found to lie above the experimental one. For ^{193}Ir the calculations could be carried out only up to 0.5 MeV because no data are available concerning the excited levels of these target nucleus. (TTT)

3649 NUCLEAR-REACTION STUDIES IN THE NICKEL ISOTOPES: THE $^{61}Ni(p,p')^{61}Ni$, $^{61}Ni(d,d')^{61}Ni$, AND $^{60}Ni(d,p)^{61}Ni$ REACTIONS. Cosman, E. R.; Schramm, D. N.; Enge, H. A.; Sperduto, A.; Paris, C. H. (Massachusetts Inst. of Tech., Cambridge). Contract AT(30-1)-2098. Phys. Rev., 163: 1134-52 (Nov. 20, 1967). (MIT–2098-341).

The levels of ^{61}Ni were studied with the reactions $^{61}Ni(p,p')^{61}Ni$, $^{61}Ni(d,d')^{61}Ni$, and $^{60}Ni(d,p)^{61}Ni$ at bombarding energies of 7.5 MeV using the MIT-ONR Van de Graaff generator and both the single-gap and multiple-gap spectrographs. The (p,p') reaction seems to be dominated by a compound-nucleus mechanism, and served as a check that we had found all the levels below 4.0 MeV in ^{61}Ni. However, the (d,d') transitions to several states below 1.5-MeV excitation were direct and strongly enhanced. In the (d,p) reaction, 197 levels were found below 7.051 MeV in ^{61}Ni. The stripping transitions were analyzed with the distorted-wave Born-approximation code JULIE, and resulting neutron single-particle strengths $(2J + 1)S_{ln,j}$, center-of-gravity energies $E_{ln,j}$, and sum-rule strengths are given. Detailed angular distributions for the non-stripping (d,p) transitions are also given. Most of them have a distinctly oscillatory structure with respect to scattering angle,

and many are shown to be identical in shape to those found in the ^{58}Ni(d,p)^{59}Ni reaction. An averaged strength function is given for these nonstripping states, and it is discussed in terms of intermediate structure. Possible interpretations of the (d,d′) and (d,p) results related to the collective and single-particle character of the low-lying states in ^{61}Ni are presented. (auth)

3650 INELASTIC SCATTERING OF 40-MeV POLARIZED PROTONS. Fricke, M. P.; Gross, E. E.; Zucker, A. (Oak Ridge National Lab., Tenn.). Contract W-7405-eng-26. Phys. Rev., 163: 1153-69(Nov. 20, 1967). (ORNL-P-3237).

The left-right asymmetry and differential cross section for the inelastic scattering of 40-MeV polarized protons were measured over a large angular region for each of the following 2^+ excitations: 1.78 MeV in ^{28}Si, 1.41 and 2.97 MeV in ^{54}Fe, 1.45 MeV in ^{58}Ni, and 1.33 MeV in ^{60}Ni. Some asymmetry and cross-section data were also obtained for 3^- states: 6.9 MeV in ^{28}Si, 4.8 and 6.4 MeV in ^{54}Fe, 4.5 MeV in ^{58}Ni, and 4.08 MeV in ^{60}Ni. The inelastic scattering was analyzed in the distorted-wave approximation, using the collective-model extension of the optical-model potential determined by fitting elastic polarization and cross-section measurements for each target. The inelastic asymmetry and cross-section data are both reproduced with a collective-model interaction obtained by deforming the complete optical potential, including its imaginary and spin-orbit parts. (auth)

3651 NUCLEAR STRUCTURE OF $^{40\ 42\ 44\ 48}$Ca FROM INELASTIC ALPHA-PARTICLE SCATTERING. Lippincott, E. P.; Bernstein, Aron M. (Massachusetts Inst. of Tech., Cambridge). Contract AT(30-1)-2098. Phys. Rev., 163: 1170-90(Nov. 20, 1967). (MIT-2098-340).

The (α,α') reaction was studied on ^{40,42,44,48}Ca at 31-MeV incident energy with approximately 90-keV resolution and high statistics. Spin and parity assignments were made on the basis of systematics and comparison with the distorted-wave Born approximation. Levels of a given spin and parity show remarkably similar angular distributions, even though they vary widely in magnitude. This indicates experimentally that because of the strong absorption of α particles, the shape of the differential cross section implies the spin and parity of the excited level, and the magnitude indicates the transition strength. The energy levels, spin and parity assignments, and transition strengths found in this experiment are compared with previous experiments and with theoretical results. Two 4^+ states, which may be core excitations, were found in ^{40,42,48}Ca between 6- and 8.5-MeV excitation energy with an equivalent electromagnetic strength of approximately 0.5 to 3 single-particle units. Three octupole states were found in ^{40,48}Ca, six octupole states in ^{42,44}Ca, a 5^- state in ^{40,42,48}Ca, and two 5^- states in ^{44}Ca. The fractionization of the 3^- strength and the rapid and similar drop of the 3^- and 5^- strength in going from ^{40}Ca to ^{44}Ca appear to be a challenge to current ideas about the nature of these states. (auth)

3652 REACTION CROSS SECTIONS OF EXCITED NUCLEI. Dudey, N. D.; Kowalski, L.; Miller, J. M. (Columbia Univ., New York). Phys. Rev., 163: 1074-7(Nov. 20, 1967).

The possible effect of excitation energy on the reaction cross section of ^{59}Co, with protons and with α particles was investigated. The investigation was effected by comparison of the measurements of the energy spectra of the α particles emitted in the ^{62}Ni(p,a)^{59}Co and the protons emitted in the ^{56}Fe(a,p)^{59}Co reactions. From the point-by-point ratio of the two spectra at kinetic energies that correspond to the same excitation energy of the residual ^{59}Co nucleus, it is found that the ratio of inverse-reaction cross sections with protons and α particles does not differ significantly from that of the reaction cross sections with protons and α particles determined with ground-state ^{59}Co targets. (auth)

3653 NEUTRON CROSS SECTIONS OF CALCIUM AND POTASSIUM FROM 2 TO 8 MeV. Reber, J. D.; Brandenberger, J. D. (Univ. of Kentucky, Lexington). Phys. Rev., 163: 1077-83(Nov. 20, 1967).

Differential cross sections for elastic scattering of neutrons were measured for calcium at neutron energies of 2.06, 3.29, 5.30, 5.88, 6.52, and 7.91 MeV, and for potassium at neutron energies of 2.06, 3.74, 4.33, 6.52, and 7.91 MeV. The measurements were made using time-of-flight techniques and a liquid scintillation detector equipped with γ-ray discrimination. Measurements of total cross sections for both nuclei were made between 1.8 and 8.3 MeV. The experimental data were compared to optical-model calculations using the computer code ABACUS-2. Parameter-search procedures produced good fits to the cross sections. The potentials implied for the two nuclei are similar. (auth)

3654 DELAYED ALPHA EMISSION FROM ^{20}Na. Polichar, R. M.; Steigerwalt, J. E.; Sunier, J. W.; Richardson, J. Reginald (Univ. of California, Los Angeles). Contract Nonr 233-44. Phys. Rev., 163: 1084-90(Nov. 20, 1967).

The β decay of ^{20}Na proceeding to highly excited states of ^{20}Ne was studied by measuring the delayed α particles which are subsequently emitted. ^{20}Na was produced by a (p,αn) reaction on a natural magnesium target, in an external beam of 45-MeV protons from the UCLA cyclotron. A thin silicon detector and nanosecond electronics were used to suppress the large positron background usually present in this type of experiment. A method of measuring Q_α directly is discussed. α transitions from states in ^{20}Ne at 7.43, 7.84, 8.74, 9.48, 10.28, 10.86, and 11.28 MeV were observed, and their intensities were measured. (auth)

3655 MASS AND BETA DECAY OF ^{20}Na. Sunier, J. W.; Armini, Anthony J.; Polichar, R. M.; Richardson, J. Reginald (Univ. of California, Los Angeles). Contract Nonr 233-44. Phys. Rev., 163: 1091-4(Nov. 20, 1967).

The β and γ spectra of ^{20}Na were measured with a wedge-gap magnetic spectrometer and a 3-cm^3 lithium-drifted germanium detector, respectively. ^{20}Na was produced by a (p,αn) reaction on a natrual magnesium target in the UCLA cyclotron. The mass excess of ^{20}Na is measured to be 6863 ± 40 keV. The half-life of ^{20}Na is 0.408 ± 0.006 sec. Two β branches of 11.25 ± 0.04 and 5.55 ± 0.15 MeV were observed, and their relative intensities measured to be 100 ± 2 and 9 ± 1, respectively. The more energetic β branch feeds the first excited state of ^{20}Ne; the excitation energy is determined to be 1633.2 ± 1.0 keV from a study of its γ transition. The 5.55-MeV β branch establishes a link with the known delayed-α spectra from the highly excited states of ^{20}Ne, and allows one to propose a decay scheme for ^{20}Na. Limits on the intensities of possible unobserved β transitions are discussed. (auth)

3656 BETA DECAY OF ^{37}S. Wirjoamidjojo, Sudiman; Kern, B. D. (Univ. of Kentucky, Lexington). Phys. Rev., 163: 1094-7(Nov. 20, 1967).

Radioactive ^{37}S was prepared by the ^{37}Cl(n,p)^{37}S reaction, and its decay products were observed with a magnetic β-ray spectrometer and with NaI(Tl) crystal and Ge(Li) crystal γ-ray spectrometers. The β-ray groups have endpoint energies, relative intensities, and comparative half-lives of 4.75 ± 0.04 MeV (5.6 ± 0.6)%, log f_1t = 8.01; 1.64 ± 0.04 MeV, 94.0%, log f_0t = 4.38; and 1.04 ± 0.04 MeV, ~0.4%, log f_0t = 5.65. The γ rays have energies and relative intensities of 3.107 ± 0.002 MeV (99.6%) and 3.708 ± 0.004 MeV (~0.4%). No other γ rays were observed; an upper limit of 0.5% is placed on their relative intensity. Coincidence counting places an upper limit of 1% on the possibility of a cascade transition from 3.107-MeV state of ^{37}Cl. Spin-parity assignments for ^{37}Cl are $\frac{1}{2}^-$ for the 3.107-MeV state and $\frac{5}{2}^-$ for the 3.708-MeV state. The ground state of ^{37}S has odd parity and probable spin $\frac{1}{2}$. (auth)

3657 RADIOACTIVE DECAY OF ^{83}Se. Marlow, K. W. (Naval Research Lab., Washington, D. C. Univ. of Maryland, College Park); Waggoner, M. A. Phys. Rev., 163: 1098-1123 (Nov. 20, 1967).

The radioactive decay of ^{83}Se produced by ^{82}Se(n,γ) was investigated experimentally, leading to a proposed level scheme for ^{83}Br. The half-life of the long-lived decay was determined to be 22.6 ± 0.2 min, and the 70-sec half-life of ^{83m}Se was confirmed. For the long-lived decay, the various coincidence studies lead to a proposed decay scheme incorporating 29 γ rays and involving excited levels in ^{83}Br at 356, 801, 868, 1094, 1355, 1421, 1438, 1814, 2060, 2650, 2697, 2738, and 2777 keV. The 1094-keV level was found to have $T_{1/2}$ = 4.1 ± 0.1 nsec. Although coincidence measurements were not made in the study of the short-lived isomer, β- and γ-ray spectrum measurements lead to the placement of nine γ rays in the proposed decay scheme, with excited levels at 356, 1032, 1063, 2022, 2054, and 2147 keV. Log ft values, determined from the studies of β-ray spectra, have been used to limit spin and parity assignments for many of the levels, while lifetime and directional correlation measurements have provided further limitations on the assignments for a few levels. (auth)

3658 CALCULATIONS OF INELASTIC SCATTERING OF NEUTRONS BY NUCLEI. II. Auerbach, E. H. (Massachusetts Inst. of Tech., Cambridge. Brookhaven National Lab., Upton, N. Y.); Moore, S. O. Contract AT(30-2)-Gen-16. Phys. Rev., 163: 1124-34(Nov. 20, 1967). (BNL-11459).

Earlier work on the inelastic scattering of neutrons by heavy nuclei in the 1–4-MeV region is extended to the lighter elements Fe and Al. Calculations using a diffuse-edged optical-model potential defined by six parameters, including a spin-orbit term, are sufficient to describe the total and differential elastic scattering. When the Hauser–Feshbach formalism is applied, inelastic-scattering calculations consistent with the above model fit the experimental data reasonably well. The relation to models requiring additional parameters is discussed. (auth)

3659 THRESHOLD PHOTONEUTRON CROSS SECTION FOR ^{56}Fe. Bowman, C. D.; Sidhu, G. S.; Berman, B. L. (Univ. of California, Livermore). Contract W-7405-eng-48. Phys. Rev., 163: 951-8(Nov. 20, 1967). (UCRL-70473).

Individual levels of the compound nucleus ^{56}Fe at an excitation energy of 11.2 MeV were studied by examining the (γ,n) cross section for natural iron from 0.7 to 70 keV above threshold with high resolution. The technique is generally applicable to the high-resolution study of photoneutron cross sections for photons whose energy exceeds the photoneutron threshold by an amount of the order of keV. Resonance parameters were obtained for certain favorable cases. The γ-ray strength function $\langle \Gamma_{\gamma 0}/D \rangle$ for electric dipole absorption in ^{56}Fe was found to be 3.5×10^{-5}, which is a factor of 2 lower than the estimates obtained either from the low-energy wing of the giant dipole resonance or from the single-particle model of the nucleus. (auth)

3660 GAMMA RAYS FROM THERMAL NEUTRON CAPTURE IN MANGANESE, GERMANIUM, AND IRIDIUM NUCLEI. Dorioman, D. I.; Popa, M. S.; Cristu, M. I. (Inst. of Atomic Physics, Bucharest). Rev. Roum. Phys., 12: 561-75(1967).

By using a solid-state Ge(Li) gamma spectrometer the thermal neutron capture spectra of Mn, Ge, and Ir were measured. Previously reported low-energy transitions were found in manganese; they were ascribed to the ^{56}Mn level scheme as known to date. The transitions found in the germanium capture spectrum were ascribed to the Ge isotopes by making use of the additional information on the gamma spectra from the Ge(n, n' gamma) reaction as obtained in this work. The single and coincidence spectra measured in Ir made possible to construct a tentative level scheme of ^{193}Ir and ^{194}Ir nuclei. A discussion of the results is given which considers the single-particle configurations of the low energy levels of these nuclei. (auth)

3661 SCATTERING CROSS SECTIONS OF GAMMA RAYS IN ALUMINIUM IN THE ENERGY REGION FROM 40 TO 411 keV. Parthasaradhi, K. (Andhra Univ., Waltair, India). Nuovo Cim. (10), 51B: 561-5(Oct. 11, 1967).

The total cross sections for photon reactions with Al were measured at seven photon energies from 40 to 411 keV. Values for the scattering cross sections at the same energies were obtained by subtracting theoretical predictions for the photoelectric cross sections from the total cross sections. The results were compared with theoretical predictions for the scattering cross sections. (D.C.W.)

3662 GAMMA RADIATION FROM ^{76}As. Aten, Jacob; Marsol, Claire; Forest, Hugues (Faculte des Sciences, Nice). Compt. Rend., Ser. C, 265: 465-7(Aug. 21, 1967). (In French).

The gamma radiation from ^{76}As was studied by means of a semiconductor pair spectrometer. Several new gammas were observed. The energy of several excited states of ^{76}Se were determined exactly. (tr-auth)

3663 RANGE-ENERGY TABLE FOR HEAVY PARTICLES IN SILICON. Bichsel, Hans; Tschalaer, Christoph (Univ. of California, Berkeley). Contract W-7405-eng-48. Nucl. Data, Sect. A 3: 343-60(Oct. 1967). (UCRL-17663).

Stopping-power (S) and range (R) tables for protons, deuterons, tritons, ^{3}He, ^{4}He, and ^{7}Li ions of energies between 1 and 200 MeV penetrating silicon absorbers are presented. Ausiliary data are included in tables for the coefficients C and α needed for the approximate expression $S = C \cdot E^{\alpha}$ and in figures giving the energy dependence for the coefficients of $R = C_R \cdot E^{\alpha}$. Included is a short review of principles to be considered in detector applications. (auth)

3664 DECAY OF THE ISOMER ^{69m}Zn. Demichelis, F.; Oldano, C. (Istituto di Fisica Sperimentale del Politecnico, Turin). Nuovo Cim. (10), 51B: 341-6(Oct. 11, 1967).

The k-conversion coefficient of the 0.436-MeV transition in ^{69m}Zn was measured. The result $\alpha_K = 0.50 \pm 0.008$ is in excellent agreement with the theoretical value calculated by Rose. A multipolarity assignment was made, and the spin and parity of the 0.436-MeV level were established. (auth)

3665 THE RATIO OF THE LARMOR FREQUENCY OF ^{73}Ge RELATIVE TO ^{2}H AND ^{41}K. Lutz, O.; Schwenk, A.; Zimmermann, G. (Univ., Tuebingen, Ger.). Phys. Lett., 25A: 653-4(Nov. 6, 1967).

The frequency of the nuclear magnetic resonance of ^{73}Ge relative to ^{2}H and ^{41}K was measured: $\nu_{^{73}Ge}/\nu_{^2H} = 0.2272473 \pm 0.0000010$ and $\nu_{^{73}Ge}/\nu_{^{41}K} = 1.3619607 \pm 0.0000005$. The magnetic moment of ^{73}Ge was evaluated. (auth)

3666 POSITRON DECAY OF ^{22}Mg. Gallmann, A.; Frick, G.; Warburton, E. K.; Alburger, D. E.; Hechtl, S. (Brookhaven National Lab., Upton, N. Y.). Contract AT(30-2)-Gen-16. Phys. Rev., 163: 1190-7(Nov. 20, 1967). (BNL-11183).

The positron decay of ^{22}Mg to excited states of ^{22}Na was investigated using the ^{20}Ne(^{3}He, n)^{22}Mg reaction to form ^{22}Mg. The relative cross section for the ^{20}Ne(^{3}He,n)^{22}Mg(β^+)^{22}Na reaction was measured as a function of ^{3}He energies between 2.0 and 5.0 MeV. A half-life of 4.03 ± 0.05 sec was obtained for ^{22}Mg. In addition to the main positron branches to the ^{22}Na 0.657- and 0.583-MeV levels, which were measured to be 59 ± 6% and 36 ± 6%, respectively, a branch of 5.1 ± 0.4% was observed leading to the 1.937-MeV level of ^{22}Na. The log ft for this branch is 3.55 ± 0.04, which establishes the 1.937-MeV level as 1^+. Upper limits were placed on positron branches to all other excited states of ^{22}Na below an excitation energy of 3.6 MeV. The 0.657 → 0.583 transition in ^{22}Na was found to have an energy of 73.9 ± 0.1 keV. An incidental result was a value of 472.3 ± 0.1 keV for the energy of the γ-ray transition from the isomeric first-excited state of ^{24}Na. (auth)

3667 INELASTIC ELECTRON SCATTERING FROM ^{58}Ni, ^{60}Ni, AND ^{62}Ni. Duguay, M. A.; Bockelman, C. K.; Curtis, T. H.; Eisenstein, R. A. (Yale Univ., New Haven). Contract AT(30-1)-2726. Phys. Rev., 163: 1259-77(Nov. 20, 1967).

Form factors are reported for the inelastic scattering of electrons from ^{58}Ni, ^{60}Ni, and ^{62}Ni over the momentum-transfer range from 0.25 to 0.53 F^{-1}. Reduced radiative transition probabilities B(EL) and transition radii R_{tr} are extracted from the data, notably for the first quadrupole and octupole states of the three isotopes. The transition radii obtained are compared to those of other nuclei. (auth)

3668 GAMMA RAYS FROM FAST-NEUTRON SCATTERING IN ^{54}Fe. Benjamin, R. W.; Morgan, I. L. (Texas Nuclear Corp., Austin). Contract AT(40-1)-2791. Phys. Rev., 163: 1252-8 (Nov. 20, 1967). (ORO-2791-25).

Cross sections for the production of γ rays by the inelastic scattering of neutrons in ^{54}Fe were measured for incident neutron energies in the range 1.81 to 5.25 MeV_{lab}. γ-ray angular distributions were measured for γ radiation of sufficient intensity at neutron energies of 1.81 and 4.0 MeV. The angular distributions compare favorably in shape with the theoretical predictions of the Satchler formalism using the neutron penetrabilities of Beyster and of Perey and Buck, but there are small differences in absolute cross sections which can be resolved in part through the incorporation of a correction for Moldauer level-width fluctuations. A multipole amplitude mixing ratio of $0 \leq \delta \leq +2.2$ was determined for the M1, E2 transition from the 2.961-MeV(2^+) to the 1.409-MeV(2^+) level. Branching ratios for the γ rays stemming from the 2.961-MeV level and the 3.161-MeV level were also determined experimentally. (auth)

3669 STUDY OF THE LOW LEVELS OF ^{27}Si. Lewis, M. B. (Duke Univ., Durham, N. C.); Roberson, N. R.; Tilley, D. R. Phys. Rev., 163: 1238-51(Nov. 20, 1967).

The low-lying excited levels of ^{27}Si were studied by the ^{26}Si (^{3}He, αγ)^{27}Si reaction. The particle-γ angular-correlation method of Litherland and Ferguson was used. Most probable spin assignments for the 0.96-, 2.17-, and 2.65-MeV levels were determined as $^3/_2$, $^1/_2$, and $^5/_2$, respectively. Transitions from the 3.54- and 4.13-MeV levels appeared to have isotropic γ-ray angular correlations, and decayed primarily through the well established $J = ^1/_2$ level at 0.78 MeV. A spin assignment of $^1/_2$ is likely for these two levels, although a $J = ^3/_2$ assignment cannot be rigorously ruled out. The branching scheme for the decay of the 3.80-MeV level suggests a spin of $^3/_2$ for this level although an angular correlation was not carried out. The levels at 2.87 and 2.91 MeV were not resolved, and an angular correlation for these levels was not carried out. The γ-ray spectra for the doublet indicate a strong ground-state transition for both levels. Mixing ratios and branching ratios for many of the γ-ray decays were measured for the first nine levels. Strong- and weak-coupling model calculations were carried out, and the results indicate significant evidence for ^{28}Si core-excitation configuration in the ^{27}Si levels below 3.00 MeV. Many transition properties predicted by the strong-coupling (rotational) model are in conflict with measured values. (auth)

3670 EFFECT OF STRIPPING CHANNELS UPON THE ELASTIC SCATTERING OF DEUTERONS FOR THE NUCLEUS OF CALCIUM. Rawitscher, George H. (Univ. of Connecticut, Storrs. Brookhaven National Lab., Upton, N. Y.). Phys. Rev., 163: 1223-38(Nov. 20, 1967).

Stripping channels are phenomenologically coupled to the incident deuteron channel, and the effect upon the elastic cross section is calculated for incident energies at 7, 11, 12.8, 14.3, and 22 MeV. Only the stripping to the 2p states in ^{41}Ca is explicitly considered, and the corresponding stripping cross sections are also obtained.

The spins of all particles are set equal to zero, and the nonorthogonality between stripping and deuteron channels is ignored to a large extent. It is found that the deuteron amplitude is significantly reduced in the nuclear interior compared to that calculated with an optical model. This reduction has an effect upon the stripping cross section which is reminiscent of a cutoff in distorted-wave Born approximation calculations, but does not appreciably affect the main stripping peaks. The agreement with experiment is not unreasonable. (auth)

3671 SPIN AND BRANCHING OF THE 2750-keV LEVEL IN ^{37}K. Goosman, D. R. (California Inst. of Tech., Pasadena). Phys. Rev., 163: 1219-22(Nov. 20, 1967).

Previous work has shown that the spin of the 2750-keV level in ^{37}K is either $3/2^+$ or $5/2^+$. To resolve the ambiguity, two experiments were carried out. The linear polarization of the ground-state γ ray from the 2750-keV level was measured. The weak cascade from the 2750-keV level through the doublet near 1.37 MeV was shown to involve the 1380-keV level. These results exclude a spin of $3/2^+$ for the 2750-keV level, and the spin is established to be $5/2^+$. (auth)

3672 NUCLEAR STRUCTURE OF THE NICKEL ISOTOPES. Auerbach, N. (Yale Univ., New Haven). Phys. Rev., 163: 1203-18(Nov. 20, 1967).

The nickel isotopes are described in terms of strongly admixed spherical shell-model configurations of neutrons occupying the $2p_{\frac{1}{2}}$, $1f_{\frac{5}{2}}$, and $2p_{\frac{3}{2}}$ orbits. A set of effective-interaction matrix elements is deduced which accurately reproduces the spectra of the Ni isotopes from ^{58}Ni to ^{67}Ni. The wave functions resulting from the calculation of the energy levels are then used to calculate the single-nucleon spectroscopic factors. These are in fairly good agreement with the experimental spectroscopic factors found in pickup and stripping experiments. In addition, some of the results from two-nucleon transfer reactions are compared with the predictions of the present model. Using the wave functions obtained and an effective charge for the neutron, the E2 transition probabilities in the even-mass isotopes of Ni are calculated and are found to be in agreement with experimental facts. (auth)

3673 NEUTRON PICKUP REACTIONS ON ^{30}Si. Dehnhard, D.; Yntema, J. L. (Argonne National Lab., Ill.). Phys. Rev., 163: 1198-1203(Nov. 20, 1967).

The neutron pickup reactions ^{30}Si(d,t)^{29}Si and ^{30}Si(^{3}He,α)^{29}Si were studied. The results indicate that the neutron configuration of ^{30}Si contains about equal components of $1d_{\frac{3}{2}}$ and $2s_{\frac{1}{2}}$ neutrons. A small f-wave neutron component in the ground-state wave function was also found. Strong transitions with $l = 2$, $J^\pi = 3/2^+$ were observed to levels at 2.03, 4.89, 6.72, and 8.32 MeV. The latter is probably the isobaric analog to the ground state of ^{29}Al. The levels at 4.08 MeV was not excited. The results are compared with the neutron stripping reaction ^{28}Si(d,p)^{29}Si and with experiments on the γ decay of the states of ^{29}Si. (auth)

3674 NEUTRON RADIATIVE CAPTURE CROSS SECTIONS FOR ^{23}Na, ^{55}Mn, ^{115}In, AND ^{165}Ho IN THE ENERGY RANGE 1.0 TO 19.4 MeV. Menlove, H. O. (Lockheed Research Lab., Palo Alto, Calif.); Coop, K. L.; Grench, H. A.; Sher, R. Phys. Rev., 163: 1299-1308(Nov. 20, 1967).

Activation cross sections for the ^{23}Na(n,γ)^{24}Na, ^{55}Mn(n,γ)^{56}Mn, ^{115}In(n,γ)^{116m}In, and ^{165}Ho(n,γ)^{166}Ho reactions were measured at 17 neutron energies between approximately 1.0 and 19.4 MeV. Neutrons were produced by means of the T(p,n)^{3}He, D(d,n)^{3}He, ^{9}Be(α,n)^{12}C, and T(d,n)^{4}He reactions using a 3.5-MeV Van de Graaff accelerator. The measurements were made relative to the fission cross section of ^{235}U for fast neutrons. Thermal irradiations were made in order to obtain cross sections normalized to the thermal activation cross sections of the irradiated samples and the thermal fission cross section of ^{235}U. The experimental cross-section data for all the isotopes investigated show evidence of a peak in the vicinity of 14 MeV. The measured capture cross sections were compared with the cross sections predicted by the "direct-capture" reaction theory of Lane and Lynn and by the "semidirect" reaction theory of Brown. (auth)

3675 CALCULATION OF THE LEVELS OF Ni AND Sn ISOTOPES BY THE QUASIPARTICLE METHOD. Raj, Ram (Saha Inst. of Nuclear Physics, Calcutta); Gambhir, Y. K.; Pal, M. K. Phys. Rev., 163: 1004-10(Nov. 20, 1967).

A modified Tamm-Dancoff approximation, developed in a previous paper, was applied to even Ni and Sn isotopes. Detailed spectra, E2 transition strengths connecting various levels, and the quadrupole moment of the first excited 2^+ level were calculated; and the trends of the results were compared with experimental values. The method appears to be fairly satisfactory. It points to the necessity of more reliable information on the effective interaction, active single-particle orbitals, and single-particle radial functions in order that a dependable quantitative fit to the data can be achieved. (auth)

3676 ELASTIC AND INELASTIC SCATTERING OF 49.5 MeV PROTONS BY ^{24}Mg. Rush, A. A. (King's Coll., London); Burge, E. J.; Lewis, V. E.; Smith, D. A.; Ganguly, N. K. Nucl. Phys., A104: 340-52(1967).

Measurements are reported of the differential cross sections for the elastic scattering of 49.5 MeV protons by ^{24}Mg and for the inelastic scattering leading to the first six excited states at 1.37, 4.12, 4.23, 5.22, 6.00, and 6.44 MeV. Simple optical-model fits to the elastic data and to polarization values are given. The best fits were obtained for a spin-orbit potential of smaller radius than that of the real central potential. Considerable improvement to the fit was obtained for values of the volume absorption radius and diffuseness which were less than those of the surface absorption potential. (auth)

3677 THE LEVEL STRUCTURE OF ^{51}V, ^{53}Mn, AND ^{55}Co BY (^{3}He,d) REACTIONS. O'Brien, B. J.; Dorenbusch, W. E.; Belote, T. A.; Rapaport, J. (Massachusetts Inst. of Tech., Cambridge). Contract AT(30-1)-2098. Nucl. Phys., A104: 609-32(1967). (MIT-2098-366).

The ^{50}Ti(^{3}He, d)^{51}V, ^{52}Cr(^{3}He, d)^{53}Mn, and ^{54}Fe(^{3}He, d)^{55}Co reactions were investigated using incident ^{3}He ions of 10, 11, and 12 MeV, and ground-state Q-values of 2.555 ± 0.015, 1.070 ± 0.015 and -0.428 ± 0.015 MeV were measured for these reactions, respectively. Deuteron spectra were obtained at 23 scattering angles between 7.5° and 172.5°. A distorted-wave analysis of these data was carried out to obtain l_p values and spectroscopic strengths. The results are compared with other experimental results and with shell-model predictions. The low-lying, even-parity states are discussed in terms of target core excitations. (auth)

3678 THE 4.88 AND 5.36 MeV STATES IN ^{38}Ar. Roepke, H.; Lieb, K. P.; Brundiers, H. (Univ., Freiburg i. B.). Nucl. Phys., A104: 529-37(1967).

The gamma decay of several ^{38}Ar states up to $E_x = 5.36$ MeV was investigated by the ^{35}Cl(α,pγ) reaction at $E_\alpha = 10.6$ MeV. From p-γ angular correlation measurements, the following spin-parity assignments were obtained: $J^\pi(4.88) = 3^+(3^-)$, $J^\pi(5.36) = 2^+, 1^+$. Possible multipole mixing ratios are given. (auth)

3679 A NUCLEAR STRUCTURE STUDY OF ^{23}Na BY MEANS OF THE ^{22}Ne(^{3}He,d)^{23}Na REACTION. Dubois, J. (California Inst. of Tech., Pasadena). Nucl. Phys., A104: 657-76(1967).

Energy levels between 2 and 9 MeV in ^{23}Na were investigated by means of magnetic analysis of the deuterons from the ^{22}Ne(^{3}He, d) ^{23}Na reaction at 10 and 12 MeV bombarding energies. Angular distributions were measured and from optical-model analysis using DWBA, the angular momentum transferred by the stripped protons was determined. Spectroscopic factors were also obtained and compared with predictions of the Nilsson model. It was possible to fit all observed levels up to 5.5 MeV excitation energy into rotational bands when band mixing due to the rotational and particle motions was included for the levels with positive parity. A search for the lowest $T = 3/2$ levels was also performed. Furthermore, it is proposed that the 5.992 ± 0.015 MeV level in ^{23}Mg is the $3/2^-$ hole state based on Nilsson orbit 2. (auth)

3680 COLLECTIVE STATES IN ^{59}Co. Nordhagen, R. (Univ. of Oslo); Elbek, B.; Herskind, B. Nucl. Phys., A104: 353-85(1967).

The low-lying energy levels of ^{59}Co were investigated by Coulomb excitation with 36 MeV ^{16}O ions. Reduced transition probabilities were determined from the singles yields, spins, and mixing ratios from particle-gamma angular correlations and the excited state mean lives from the Doppler shifts of gamma rays as observed by a Ge(Li) detector. The levels at 1097, 1189, and 1458 keV are strongly excited. Inelastic deuteron scattering, in addition, reveals levels at 1479 and 1743 keV. The following quantities were determined: The 1097 keV level $J^\pi = 3/2^-$, $B(E2)\uparrow = 0.005$ (units of $e^2 \times 10^{-48}$ cm^4), $\tau > 4.2$ ps. The 1189 keV level: $J^\pi = 5/2^-$ ($J^\pi = 1/2^-$ not definitely excluded) $B(E2)\uparrow = 0.022$, $\tau = 0.08 \pm 0.01$ ps. The 1458 keV level: $J^\pi = 11/2^-$ ($5/2^-$), $B(E2)\uparrow = 0.012$, $\tau = 1.6 \pm 0.4$ ps. An appendix gives general methods for the treatment of Doppler shift data from Coulomb excitation. (auth)

3681 COULOMB EXCITATION OF ^{75}As. Robinson, R. L.; McGowan, F. K.; Stelson, P. H.; Milner, W. T. (Oak Ridge National Lab., Tenn.). Nucl. Phys., A104: 401-16(1967). (ORNL-P-3268).

Coulomb excitation of ^{75}As was effected with 3.5 to 8.1 MeV alpha particles and 36 to 38 MeV ^{16}O ions. The resulting gamma rays were measured with NaI crystals and Li-drifted Ge detectors. From the gamma-ray energies and yields as determined from

singles and gamma–gamma coincidence spectra and from gamma-ray angular distributions, information has been deduced about the properties of eight levels and the gamma rays deexciting them. The energies in keV, the $B(E2)_{ex}$ values in units of e^2fm^4 and the spins for the odd-parity levels are 198.6 ± 0.1, 161 ± 14, ½; 264.7 ± 0.3, 47 ± 5, ⅜; 279.6 ± 0.3, 448 ± 40, ½; 468.8 ± 0.4, 33 ± 3, ½; 572.3 ± 0.2, 730 ± 70, ½; 617.7 ± 0.6, 10.8 ± 2.6, (½, ⅜) and 821.8 ± 0.2, 1070 ± 100, ½. The B(M1) values for the gamma rays ranged from <0.003 to 0.19 X $(eh/2Mc)^2$. There was evidence that the even-parity state at 401 keV was populated by E3 Coulomb excitation. The B(E3) is (385 ± 130) e^2fm^6 or 1.2 times the single-particle estimate. This gives a value of 1.6×10^5 for the E1 to E3 radiative admixture for the 401 keV gamma ray. (auth)

3682 SOFT CORE POTENTIAL AND THS SHELL MODEL OF ^{50}Ti. Aggarwal, Gian; Kumar, Naresh (Panjab Univ., Chandigarh, India). Progr. Theor. Phys. (Kyoto), 38: 510-12 (1967).

An attempt was made to select a suitable soft-core potential by studying the effect of different values of the hardness parameter. The position of the 6^+ state of ^{50}Ti was calculated using the shell model with three different values of the hardness parameter. (D.C.W.)

3683 RADIATIVE CAPTURE CROSS SECTIONS FOR 3-MeV NEUTRONS. Peto, G.; Miligy, Z.; Hunyadi, I. (Inst. of Nuclear Research, Debrecen, Hungary). J. Nucl. Energy, 21: 797-801 (Oct. 1967).

Radiative capture cross sections were measured for 28 nuclei between A = 27 and A = 197 for 3-MeV neutrons. A plot of $\sigma_{n,\gamma}$ against the target neutron number shows that the trends obtained are quite similar to the trends appearing at 1- and 14-MeV neutron energies. (auth)

3684 ANALYSIS OF S AND Cl WAVE FUNCTIONS BY DIRECT REACTIONS. Fazio, M.; Micheletti, S.; Pignanelli, M.; Zetta, L. (Univ., Milan. Istituto Nazionale di Fisica Nucleare, Milan). Nuovo Cim. (10), 51B: 459-74(Oct. 11, 1967).

The deuteron energy spectrum and the angular distributions to the ground and 2.13- and 3.31-MeV excited states of ^{34}S were measured for the reaction ^{35}Cl(n,d)^{34}S. These results and the available experimental data of stripping and pick-up reactions on S and Cl isotopes are analyzed using the DWBA, and spectroscopic factors for several transitions are obtained. These factors are then compared with those predicted on the basis of the shell and collective rotational models. A good agreement is found with the predictions of the shell model in which phenomenological two-body matrix elements are used. (auth)

3685 EXPERIMENTAL STUDY OF THE REACTION ^{32}S(^{3}He,α)^{31}S. Rotbard, G.; Kalifa, J.; Ronsin, G.; Vergnes, M. (Institut de Physique Nucleaire, Orsay, France). J. Phys. (Paris), 28: 637-41(Aug.-Sept. 1967). (In French).

The reaction ^{32}S(^{3}He,α)^{31}S was studied with a 7.6 MeV ^{3}He beam. The Q-value of the reaction and the energies of the first 15 excited states in ^{31}S were measured. The α-particle angular distributions in the reactions leading to the ground state and to the first six levels are presented. (auth)

Nuclear Properties and Reactions, A ≥ 90

Refer also to abstracts 2087, 3256, 3624, 3643, 3648, 3660, 3674, 3675, 3683, 3770, 3781, and 3796.

3686 (BNL-11903) RADIATIVE CAPTURE OF NEUTRONS IN AND BETWEEN RESONANCES. Chrien, R. E. (Brookhaven National Lab., Upton, N. Y.). Nov. 7, 1967. 21p. (CONF-671040-1). Dep. CFSTI.

From Meeting of the Division of Nuclear Physics, Madison, Wis.

The advantages of epithermal capture for studying nuclear parameters are outlined and are demonstrated by several recent experiments that were performed at the BNL HFBR using a chopper time-of-flight facility designed specifically for such spectral studies. Differences between the spectra from resonance and thermal capture in ^{197}Au and ^{169}Tm are discussed, together with evidence for potential capture in ^{238}U. An investigation of p-wave capture using epithermal capture in ^{118}Sn is also summarized. (D.C.W.)

3687 (EURFNR-404) SOME NEW MEASUREMENTS AND RENORMALIZATIONS OF NEUTRON CAPTURE CROSS SECTION DATA IN THE keV ENERGY RANGE. Poenitz, W. P.; Kompe, D.; Menlove, H. O.; Beckurts, K. H. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Angewandte Kernphysik). Oct. 1967. 14p. (EUR-3679e; KFK-635; CONF-671043-9). Dep. CFSTI.

Work performed under United States–Euratom Fast Reactor Exchange Program.

From Symposium on Fast Reactor Physics and Related Safety Problems, Karlsruhe, Germany.

The absolute neutron capture cross section of Au was measured for neutron energies of 25 to 500 keV to an accuracy of about ±5%. Absolute normalization of the relative cross-section curve was performed at a neutron energy of 30 keV. The capture cross section of ^{238}U was measured over the same energy range. The capture cross sections, relative to Au, of a number of medium-weight and heavy nuclides were measured, using a time-of-flight method and a large liquid scintillator tank, in the energy range from 10 to 150 keV. Evaluated data are presented for Cs, Hf, Mo, Nb, Re, Ta, and W. The implications of the new data for fast reactor calculations were studied. (D.C.W.)

3688 (FEI-73) UGLOVOE RASPREDELENIE OSKOLKOV FOTODELENIYA VBLIZI POROGA. (Angular Distribution of Fragments of Photofission Near the Threshold). Rabotnov, N. S.; Smirenkin, L. N.; Soldatov, A. S.; Usachev, L. N. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Obninsk, Fiziko-Energeticheskii Institut); Kapitsa, S. P.; Tsipenyuk, Yu. M. (Akademiya Nauk SSSR, Moscow. Institut Fizicheskikh Problem). 1966. 7p. (In Russian). Dep.

The results of the measurement of the angular distribution of fission fragments of the nuclei ^{232}Th, ^{238}U, ^{240}Pu, and ^{242}Pu with γ quanta of bremsstrahlung in the energy interval from 5 to 8 MeV are reported. All expected consequence of the significant differences in the threshold between channels with different K were observed experimentally. The results supported the hypothesis of the existence of approximation laws on the conservation of the quantum number K under moderate excitation energy. (J.S.R.)

3689 (GA-7820) RADIATIVE CAPTURE CROSS SECTION MEASUREMENTS. Summary Report, March 1, 1966–February 28, 1967. Lopez, W. M.; Friesenhahn, S. J.; Froehner, F. H. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). Feb. 20, 1967. Contract AT(04-3)-167. 26p. Dep. CFSTI.

Neutron capture and total cross sections for ^{185}Re and ^{187}Re were measured, and resonance parameters were determined for 58 levels in the resolved resonance region of 1 to 100 eV. A resonance absorption integral of 820 ± 50 b was calculated for normal Re from the results. Resonance parameters for ^{91}Zr were derived from neutron-capture data. Computer programs for the analysis of neutron resonance data were written. The use of neutron-capture data for the determination of the spins of energy levels was investigated; the technique was applied to three levels of ^{91}Zr. A 4000-liter liquid scintillator was modified, by optically decoupling the detector into two separate halves and requiring coincidence between the signals from the two halves, to operate in a coincidence mode that would reduce background count rates. (D.C.W.)

3690 (GEAP-5356) A SURVEY AND EVALUATION OF THERMAL FISSION YIELDS FOR ^{235}U, ^{239}Pu, ^{233}U, AND ^{241}Pu. Rider, B. F.; Ruiz, C. P.; Peterson, J. P. Jr.; Smith, F. R. (General Electric Co., Pleasanton, Calif. Nuclear Technology Dept.). Sept. 1, 1967. Contract AT(04-3)-189. 51p. Dep. CFSTI.

The accurate determination of atom percent fission (burnup) in nuclear fuel by the fission product-to-fuel ratio method requires the use of accurate fission yields in the calculation. Recent measurements of chain yields in thermal-neutron induced fission of U-235, Pu-239, U-233, and Pu-241 have been made to improve the accuracy of fission yields. Fission yield accuracies of several mass chains used for burnup analysis now approach 2% at the 95% confidence level. Thermal fission yields published through June 1967 are compiled and are evaluated. From this compilation a set of thermal fission yields is prepared for use in nuclear fuel burnup analysis. (auth)

3691 (IFA-CRD-34) A STUDY OF THE SPONTANEOUSLY FISSIONING ISOMER OF ^{242}Am THROUGH ^{241}Am(n,γ) REACTION. Flerov, G. N.; Pleve, A. A.; Polikanov, S. M.; Tretyakova, S. P.; Boca, I.; Sezon, M.; Vilcov, I.; Vilcov, N. (Academia R. P. R.; Bucharest. Institutul de Fizica Atomica). May 1967. 9p. Dep.

The excitation function for the ^{241}Am(n,γ)^{242}Am reaction leading to the excitation of the 14-ms spontaneously fissioning isomer was studied using neutrons with energies in the range 0 to 6.5 MeV. The experimental results can be well explained taking into account the hypothesis of Strutinsky concerning the "shape isomerism". (auth)

3692 (INR-814/I/PL) ENERGY SPECTRUM OF ALPHA PARTICLES FROM THE ^{122}Te(n,α)^{119}Sn AND ^{169}Tm(n,α)^{166}Ho

REACTIONS WITH 14.2-MeV NEUTRONS. Jaskola, M.; Osakiewicz, W.; Turkiewicz, J.; Wilhelmi, Z. (Institute of Nuclear Research, Warsaw (Poland)). 1967. 12p. Dep.

The energy spectrum of alpha particles from the $^{122}Te(n,\alpha)^{119}Sn$ and $^{169}Tm(n,\alpha)^{166}Ho$ reactions at 14.2 MeV was studied using the semiconductor detector technique. The analysis of the energy spectrum leads to results that the evaporation theory is inadequate to the description of the investigated reactions. The shapes of the experimental spectra suggest the presence of strong direct effects in the investigated reactions. (auth)

3693 (INR-822/IA/PL) ENERGY SPECTRA OF LONG RANGE PARTICLES FROM THE THERMAL NEUTRON FISSION OF ^{235}U. Dakowski, M.; Chwaszczewska, J.; Krogulski, T.; Piasecki, E.; Sowinski, M. (Institute of Nuclear Research, Warsaw (Poland)). 1967. 11p. Dep.

Energy spectra of ^{1}H, ^{2}H, ^{3}H, ^{4}He, and ^{6}He from the thermal-neutron fission of ^{235}U were investigated using a semiconductor counter telescope and two-parameter analysis. Gaussian distributions were fitted to the measured distributions with the least squares method. Relative intensities were calculated. (auth)

3694 (INSJ-105) LIST OF MEMBERS OF QUASI-GROUND, QUASI-BETA, AND QUASI-GAMMA BANDS. Sakai, Mitsuo (Tokyo Univ. (Japan). Inst. for Nuclear Study). Sept. 1, 1967. 25p. Dep.

Excited levels in even-even nuclei are classified into so-called quasi-ground, quasi-beta and quasi-gamma bands which have been observed in all the nuclear regions. The experimental compilation indicates that the heads of the quasi-beta and quasi-gamma bands are more of collective character and have a larger effective moment of inertia than for the ground state. (auth)

3695 (JINR-P6-3541) O TSEPOCHKE RASPADA $^{138}Nd \rightarrow {}^{138}Pr \rightarrow {}^{138}Ce$. (On the Decay Chain of $^{138}Nd \rightarrow {}^{138}Pr \rightarrow {}^{138}Ce$). Buttsev, V. S.; Zhelev, Zh. T.; Kalinnikov, V. G.; Kudryavtseva, A. V.; Liptak, Ya.; Molnar, F.; Nazarov, U.; Urbanets, Ya. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1967. 18p. (In Russian) Dept.

The more exact data on the decay of $^{138}Nd \rightarrow {}^{138}Pr \rightarrow {}^{138}Ce$ are given. It is established that by the decay of ^{138}Pr (1.5 min) the levels $0(0^+)$, $787.1(2^+)$, $1473.8(0^+)$ and 1510 keV (2^+) are excited in the ^{138}Ce nucleus. The mass difference of the ^{138}Pr and ^{138}Ce nuclides, determined with great accuracy, is found to be Q_β = 4437 ± 10 keV. The nature of ^{138}Ce levels is discussed. An approximate level of 326 keV, excited by the decay of ^{138}Nd in ^{138}Pr nuclei, is introduced. It is established that ^{138}Pr isomeric state (2.2 h) is by 363 ± 30 keV higher than the main state. (auth)

3696 (JINR-P7-3556) O SVOISTVAKH NEKOTORYKH IZOTOPOV 102-GO I 103-GO ELEMENTOV. (On the Properties of Some Isotopes of Elements 102 and 103). Flerov, G. N.; Akapev, G. N.; Demin, A. G.; Druin, V. A.; Lobanov, Yu. V.; Fefilov, B. V. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Reactions). 1967. 20p. (In Russian). Dep.

In the reactions $^{238}U(^{22}Ne,5n)^{255}102$ and $^{239}Pu(^{18}O,5n)^{252}102$, the α-decay properties of $^{255}102$ (E_α = 8.08 ± 0.03 MeV; $T_{\frac{1}{2}}$ = 3.0 ± 0.2 min) and $^{252}102$ (E_α = 8.41 ± 0.03 MeV; $T_{\frac{1}{2}}$ = 3 sec) isotopes are studied. The data on the spontaneous fission of the $^{238}U + {}^{18}O$ reaction products are given. According to Ghiorso et al., the partial spontaneous fission half-life of $^{252}102$ should be considered only as a lower limit. The data on the properties of $^{256}103$ (E_α = 8.35 − 8.55 MeV; $T_{\frac{1}{2}}$ = 0.4 min) are presented. (auth)

3697 (KFK-534) SCHNELLE RADIOCHEMISCHE TRENNUNG SELTENER ERDMETALLE UND EINIGE KERNZERFALLSDATEN DER NUKLIDE ^{139}Pm, ^{140}Pm, ^{141}Pm, ^{141}Sm, ^{142}Sm, UND ^{143}Sm. (Fast Radiochemical Separation of Rare Earth Metals and Some Nuclear Decay Data for the Nuclides ^{139}Pm, ^{140}Pm, ^{141}Pm, ^{141}Sm, ^{142}Sm, and ^{143}Sm). Bleyl, Hans-Juergen (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Radiochemie). Feb. 1967. 50p. (In German). Dep.

For development of a fast separation of neighboring rare earth metals, some parameters of elution chromatography in cation exchange columns were investigated extensively. It was shown that the most suitable values of the distribution coefficients can be determined with a simple optimization method. With use of the optimum working conditions, it is possible, from a mixture of a maximum of 200 μg of the lanthanides Pm, Nd, and Pr or Sm, Pm, and Nd to separate 50% of the elements with the highest atomic number within three minutes with enrichments $>10^3$. α-hydroxybutyric acid was used as the complexing reagent instead of α-methyl-α-hydroxybutyric acid. This increases the corresponding separation time by a factor of 2. By (d,xn) or (α,xn) reactions with ^{142}Nd the neutron-deficient radioisotopes, ^{139}Pm, ^{140}Pm, ^{141}Pm, ^{141}Sm, ^{142}Sm, and ^{143}Sm were produced. The ^{139}Pm, ^{140}Pm, and ^{141}Sm were previously unknown. From measurements of their decay activity and γ spectra, their half-lives and the energies and relative intensities of the γ quanta emitted in their decays were determined. The discussion of the data obtained leads to proposals for the decay schemes of the radioisotopes. (tr-auth)

3698 (KFK-616) NUCLEAR STRUCTURE STUDIES WITH RADIATIVE NEUTRON CAPTURE. Fanger, U.; Markus, G.; Michaelis, W.; Ottmar, H.; Schmidt, H. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Angewandte Kernphysik). Sept. 1967. 8p. (CONF-670910-6). Dep.

From International Conference on Nuclear Structure, Tokyo, Japan.

The energy levels of ^{58}Fe and ^{62}Ni were investigated using the $^{57}Fe(n,\gamma)^{58}Fe$ and $^{61}Ni(n,\gamma)^{62}Ni$ reactions. Spin-parity assignments were made for several levels of ^{58}Fe and ^{62}Ni, and level schemes were also proposed for the two nuclei. Gamma-gamma angular correlations in ^{88}Sr from the reaction $^{87}Sr(n,\gamma)^{88}Sr$ were measured; Legendre coefficients were determined as were spin-parity assignments for the initial states and possible shell-model configurations for these states. The level structure of the deformed nuclei ^{165}Dy, ^{167}Ev, and ^{169}Yb was also investigated using the capture technique. (D.C.W.)

3699 (ORNL-TM-1804) SIMULTANEOUS MEASUREMENTS OF THE NEUTRON FISSION AND CAPTURE CROSS SECTIONS FOR ^{235}U FOR INCIDENT NEUTRON ENERGIES FROM 0.4 eV TO 3 keV. deSaussure, G.; Gwin, R.; Weston, L. W.; Ingle, R. W. (Oak Ridge National Lab., Tenn.); Fullwood, R. R.; Hockenbury, R. W. (Rensselaer Polytechnic Inst., Troy, N. Y. Dept. of Nuclear Engineering and Science). Nov. 21, 1967. Contracts W-7405-eng-26; AT(30-3)-328. 79p. Dep. CFSTI.

The neutron fission and capture cross sections for ^{235}U were measured simultaneously for incident neutron energies from 0.4 eV to 3 keV. In addition, the fission cross section was measured up to a neutron energy of 20 keV. This memorandum contains a brief description of the experimental technique and a discussion of the results. A complete tabulation of the data is given in an appendix. (auth)

3700 (UCRL-17547(Exp.)) DETERMINATION OF Y_4 DEFORMATIONS IN THE RARE EARTH REGION BY INELASTIC ALPHA PARTICLE SCATTERING. Hendrie, D. L.; Glendenning, N. K.; Harvey, B. G.; Jarvis, O. N.; Duhm, H. H.; Mahoney, J.; Saudinos, J. (California Univ., Berkeley. Lawrence Radiation Lab.). Sept. 1967. Contract W-7405-eng-48. 21p. (CONF-670910-5). Dep. CFSTI.

From International Conference on Nuclear Structure, Tokyo, Japan.

The angular distributions of scattered alpha particles exciting members of the rotational band built on the ground state of even-even rare earth nuclei were measured. The results were compared with a theory that solves the scattering problem exactly if one assumes that the interaction can be represented by an optical potential of rigid deformed shape. The detailed agreement between theory and experiment yields for the first time accurate measurements of higher-order deformations in these permanently deformed nuclei. (D.C.W.)

3701 (WAPD-TM-612) ^{233}Pa RESONANCE INTEGRAL MEASUREMENTS. Connor, J. C.; Bayard, R. T.; Macdonald, D.; Gunst, S. B. (Bettis Atomic Power Lab., Pittsburgh, Pa.). Sept. 1967. Contract AT(11-1)-Gen-14. 17p. Dep. CFSTI.

The neutron capture resonance integral of ^{233}Pa was measured by irradiating cadmium-covered thorium wires, and, after suitable chemical separations, determining the quantity of ^{234}U produced. Results are reported for two methods of measuring the irradiating flux. Monitor wires of cobalt in aluminum alloy give integrated fluxes based upon a value of 72.0 barns for the resonance integral of ^{59}Co. Alternatively, measurements of the ^{233}U produced by the irradiations give integrated fluxes based upon an effective resonance integral of 36.5 barns measured for the ^{232}Th wires. The experiments provide ^{233}Pa resonance integral results of 846 ± 43 barns employing cobalt-monitored fluxes, and 837 ± 43 barns, employing thorium-monitored fluxes. These results, which have an average value of 842 ± 35 barns, include the 1/v component of the cross section and are appropriate for a 1/E spectrum and a perfect filter with a low energy cut-off of 0.50 eV. (auth)

3702 TIME-REVERSAL INVARIANCE IN THE BETA-DECAY OF RaE. Vinduska, M.; Sott, M. (Nuclear Research Inst., Czechoslovak Academy of Sciences, Rez). Czech. J. Phys., B17: 941-7(1967).

The question of the possible violation of time-reversal invariance in RaE beta decay was reinvestigated. The χ^2 analysis of the available experimental data on spectrum shape together with the longitudinal polarization of beta electrons lead to an upper limit

of 2^0 for the relative phase of the vector and axial vector coupling constants which is a lower value than that given in some previous papers. (auth)

3703 TERNARY FISSION OF $^{238}U_{92}$. Benisz, J.; Panek, T. (Inst. of Nuclear Physics, Krakow, Higher Pedagogical Coll., Katowice, Poland). Acta Phys. Pol., 32: 485-93(1967).

The ternary fission mechanism of ^{238}U with the emission of a particle with $Z > 2$ was investigated. Two types of ternary fission of ^{238}U were found. The first type is called the asymmetrical ternary fission, and the second type is called the symmetrical ternary fission. The two types differ by the way of tripartition. The average of the total kinetic energy of ternary fission fragments was found to be 202 MeV. The measured ratio of the ternary fission cross section to the binary fission cross section is about 10^{-3}. (auth)

3704 GAMMA RADIATION OF ^{135}Ce. Rezanka, I.; Spalek, A.; Frana, J.; Jursik, J. (Nuclear Research Inst., Czechoslovak Academy of Sciences, Rez). Czech. J. Phys., B17: 1050-2(1967).

The gamma spectrum emitted in the decay of ^{135}Ce was investigated using a Ge(Li) detector. The energies and intensities of the gamma lines were determined; the intensities were used to calculate K-conversion coefficients. Multipolarities were assigned to the various transitions. (D.C.W.)

3705 GAMMA RADIATION OF ^{136}Cs. Frana, J.; Rezanka, I.; Spalek, A.; Mastalka, A. (Nuclear Research Inst., Czechoslovak Academy of Sciences, Rez). Czech. J. Phys., B17: 1048-9(1967).

The gamma spectrum emitted in the decay of ^{136}Cs was investigated using a Ge(Li) detector. The energies and relative intensities of gamma transitions in ^{136}Ba were determined. A decay scheme including two previously unreported transitions of 110 and 187 keV is proposed for ^{136}Cs. (D.C.W.)

3706 ACTIVATION MEASUREMENT OF THE DOPPLER EFFECT FOR ^{238}U CAPTURE AND ^{235}U FISSION IN A FAST-NEUTRON SPECTRUM. Pflasterer, G. R. Jr. (General Electric Co., San Jose, Calif.); Sher, R. Nucl. Sci. Eng., 30: 374-94 (1967).

The Doppler effect in ^{238}U capture and ^{235}U fission was measured by means of a foil activation technique in the fast-neutron spectrum core of the Mixed Spectrum Critical Assembly. Experimental results were obtained for two ^{238}U foil thicknesses and one ^{235}U foil thicknesses. The amount of scattering material between the foil and surrounding core fuel was varied to determine the effect on the Doppler measurement of change in the incident flux fine-energy structure in the resonances. In this experiment, only the foil is heated, while the core fuel remains at room temperature. The experiment is analyzed by means of the collision-probability method which is used to develop and expression for the resonance integral of a thin absorber which is separated from a homogeneous reactor fuel region by a purely scattering medium. The general expression for the foil resonance integral is simplified, and numerical results are presented for the case in which the dominant resonances are weak; that is, for a fast reactor in which the 0.5- to 3.0-keV energy region dominates the ^{238}U Doppler effect. The measured ^{238}U Doppler effect expressed as the ratio $R - 1$ = (change in foil activity with temperature/room temperature foil activity) typically was of the order of 0.015 ± 0.002. This was a factor of 2 higher than that calculated using a neutron energy spectrum derived from "nominal" material cross sections. Presently available cross sections in the energy range of interest are sufficiently uncertain so that it is possible to infer from them "hard" or "soft" neutron energy spectra such that the value of R-1 varies by a factor of 2. The measured values for ^{238}U agreed quantitatively with those found from the "soft" neutron energy spectrum. Within the precision of the measurement no ^{235}U Doppler effect was observed. The calculated ^{235}U Doppler effect was smaller than the sensitivity of the experiment, thus, within its precision (±0.002), the measurement confirms the theory. (auth)

3707 PHENOMENOLOGICAL ANALYSIS OF ROTATIONAL STATES IN DEFORMED EVEN-EVEN NUCLEI. Abecasis, S. M. (IIAE, DINFIA, Buenos Aires); Bosch, H. E.; Heras, C. A. Nuovo Cim. (10), 51B: 310-14(Oct. 11, 1967).

A comparison of the rotation-vibration and the asymmetric rotor (with β vibrations) models is made with recent experimental data. For the three lowest rotational bands, good agreement with experiment is obtained. The approximate equivalence between the two models is corroborated. The consistency with calculations based on microscopic theories is also achieved. (auth)

3708 SEARCH FOR PSEUDOSCALAR INTERACTION IN THE $0^- - 0^+$ β TRANSITION IN $^{144}Pr - ^{144}Nd$. Subotowicz, M. (Curie-Sklodowska Univ., Lublin, Poland). Acta Phys. Pol., 32: 221-33 (1967).

The longitudinal polarization P_L of the electrons of 1.80 MeV from the $0^- - 0^+$ transition in ^{144}Pr was measured. The numerical analysis of the P-coupling contribution to the transition was carried out by using the results of P_L measurements as well as the results of the shape factor C(W) measurements given by Porter and Day (Phys. Rev., 114: 1286(1959)). The value obtained $|C_P/C_A| \leq 1.47 \pm 0.03$ can be treated as the upper limit of a possible contribution to the investigated transition. The possibility of experimental verification of the presence of the induced pseudoscalar interaction was excluded. The value 3.20 ± 0.06 was found for λ, the ratio of the pseudovector nuclear matrix elements. These results are in agreement with the experimental results reported by Graham et al. (Can. J. Phys., 36: 1084(1959)), Porter and Day, as well as with the theory of Rose and Osborn (Phys. Rev., 93: 1315(1954)), and especially with that of Pearson (Can. J. Phys., 38: 148(1960)). (auth)

3709 TOTAL GAMMA ENERGY RELEASE DUE TO THERMAL-NEUTRON FISSION IN ^{235}U. Holden, N. E.; Mendelson, M. R.; Dudley, T. E. (Knolls Atomic Power Lab., Schenectady, N. Y.). Nucl. Sci. Eng., 30: 461-3(1967).

A compilation and evaluation of data on the time and energy dependence of the gamma spectrum following thermal neutron fission of ^{235}U was made, and an estimate of the total gamma energy release was obtained. (D.C.W.)

3710 NEUTRON TOTAL AND ABSORPTION CROSS SECTIONS OF ^{238}Pu. Young, T. E. (Idaho Nuclear Corp., Idaho Falls); Simpson, F. B.; Berreth, J. R.; Coops, M. S. Nucl. Sci. Eng., 30: 355-61(1967).

The neutron total cross section of ^{238}Pu was measured from 0.008 to 6500 eV. These data give single-level Breit-Wigner parameters for resonances below 200 eV. The observed total cross section at 2200 m/sec is 588 b. A value of 532 b was calculated for the effective (equivalent 1/v) thermal absorption cross section. Parameters of individual resonances below 200 eV and average parameters at higher energies give a resonance absorption integral of 164 ± 15 b, and a value of $(1.10 \pm 0.20) \times 10^{-4}$ for the s-wave neutron strength function ($\overline{\Gamma_n^0}/D$). (auth)

3711 SYMMETRICAL PHOTOFISSION OF ^{238}U. Kapitsa, S. P.; Novgorodtseva, V. I.; Pchelin, V. A.; Smirenkin, G. N.; Tsipenyuk, Yu. M.; Shubko, V. M. (Inst. of Physics Problems, Moscow). JETP Lett. (USSR) (Engl. Transl.), 6: 27-8(July 15, 1967).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu, 6: 495-7(July 15, 1967).

The yield of ^{115}Cd relative to that of ^{139}Ba in the photofission of ^{238}U was measured as a function of bremsstrahlung energy from 5.4 to 6.5 MeV. A maximum in the ^{115}Cd yield similar to that observed by Shmitt and Duffield (Phys. Rev., 105: 1277(1957)) for ^{117}Cd was noted. An interpretation of the data in terms of the quadrupole fission probability or of competition of neutron emission with the fission width of the 2^+ channel was considered. (D.C.W.)

3712 ROTATIONAL STATES IN DEFORMED EVEN-EVEN NUCLEI. Gupta, Raj K. (Univ. of Toronto). Can. J. Phys., 45: 3521-32(Nov. 1967).

The deviations from the simple $I(I + 1)$ dependence of the energy levels in the ground-state rotational bands on the hydrodynamical model of Bohr and Mottelson have been investigated for both regions of stable deformation. An interpretation of high spin states is looked for in terms of a nonrigid rotator with vibrations (harmonic oscillator type) taken as perturbation. In the framework of this model, the energy expression is obtained as a power series in the product of the ratio B/A and the weight factor $I(I + 1)$, where A is related to the moment of inertia and B is the rotation-vibration coupling constant. The calculations are shown to be in good agreement with the experimental data. (auth) (CANADA)

3713 THE REACTION $Xe(n,\alpha)Te$ AT NEUTRON ENERGIES FROM 12.5 TO 18.0 MeV. Mack, G.; Tornow, W. (Univ., Tuebingen, Ger.). Z. Phys., 207: 359-74(1967). (In German).

The reaction $Xe(n,\alpha)Te$ was investigated in the neutron energy range from 12.5 to 18.0 MeV. A high-pressure gas scintillator filled either with pure xenon of natural isotopic abundance or with a mixture of xenon and helium was used as a target and as a detector simultaneously. The helium served as a monitor. (n,α) spectra were measured and were analyzed by evaporation theory. Large components of direct processes were found. The level density parameter of Te was determined to be 17.0 ± 1.7 MeV^{-1}. The cross-section excitation function is given as well as the branching ratios for evaporation and direct processes as a function of neutron energy. (auth)

3714 THE GAMMA-RAY SPECTRUM OF ^{214}Po. Buschmann, H. T.; Lauterjung, K. H. (Univ., Cologne). Z. Phys., 207: 411-27(1967). (In German).

A high-resolution gamma-ray spectrometer with a Ge(Li) de-

tector is described. The spectrometer is used as a single-crystal spectrometer as well as a three-crystal pair spectrometer with a Ge(Li) central detector and two Na-crystals for the detection of the annihilation quanta. Measurements were made of ^{214}Po. The sources were ^{222}Rn in small glass tubes. 66 gamma rays, 10 of which were previously unknown, were observed. An improved level scheme of ^{214}Po is given. (auth)

3715 NUCLEAR g-FACTORS OF THE FIRST EXCITED STATES IN ^{191}Ir AND ^{193}Ir. **Wagner, F.; Kaindl, G.; Kienle, P.; Koerner, H. J. (Technische Hochschule, Munich). Z. Phys., 207: 500-4(1967).**

Mössbauer experiments were performed to determine the nuclear g-factor of the 82 keV $\frac{1}{2}^+$ state in ^{191}Ir (g = +1.083 ± 0.009) and the 73 keV $\frac{1}{2}^+$ state in ^{193}Ir (g = +0.9400 ± 0.0019). The E2/M1 mixing parameters of the corresponding $(\frac{1}{2}^+)$ (E2/M1) $(\frac{3}{2}^+)$ transitions were found to be $|\delta|$ (^{191}Ir, 82 keV) = 0.80 ± 0.06 and δ(^{193}Ir, 73 keV) = −0.558 ± 0.005. (auth)

3716 MOESSBAUER EFFECT AND NUCLEAR MOMENTS OF THE 75-keV STATE OF ^{161}Dy AND THE 81-keV STATE OF ^{162}Dy. **Henning, W.; Heunemann, D.; Weber, W.; Kienle, P.; Koerner, H. J. (Technische Hochschule, Munich). Z. Phys., 207: 505-10(1967).**

The Mössbauer effect of the γ rays from the 74.5-keV state of ^{161}Dy and the 80.7-keV state of ^{162}Dy was investigated. From hyperfine splitting patterns the magnetic moments μ(75 keV) = −(0.39 ± 0.04) nm, μ(81 keV) = +(0.74 ± 0.08) nm, and the quadrupole moment Q(75 keV) = +(1.4 ± 0.2)b were determined. For the odd-neutron nucleus ^{161}Dy, an effective spin g factor $g_{I,eff}$ = 0.76 $g_{I,free}$ is deduced for the 75-keV level. (auth)

3717 DEPENDENCE OF FISSION-FRAGMENT ANGULAR DISTRIBUTIONS ON TARGET DEFORMATION AND SPIN. **Vandenbosch, R.; Wolf, K. L. (Univ. of Washington, Seattle); Unik, J.; Stephan, G.; Huizenga, J. R. Phys. Rev. Lett., 19: 1138-41(Nov. 6, 1967).**

Fission-fragment anisotropies were measured for the ^{235}U(d,pf) reaction at 10, 13, 15, and 21 MeV. For the measurements at 10 and 13 MeV, the proton detector was at 140°, while for the 15- and 21-MeV measurements the proton detector was at 90°. The ratio of the number of fission fragments (coincident with the proton counter) emitted parallel to the classical recoil direction to those perpendicular to the recoil direction was plotted as a function of excitation energy. The results confirm the low values of the anisotropy in the vicinity of an excitation energy of 5.3 MeV for low deuteron energies, and also indicate that the effect disappears at high energies. It is proposed that the anomalous anisotropies observed at low deuteron energies are mainly a result of the nuclear shape dependence of the Coulomb barrier penetrability for both the incident deuterons and the outgoing protons. (D.C.W.)

3718 ALPHA DECAY OF HOLMIUM NUCLEI: NEW ISOTOPE, ^{154}Ho. **Hahn, R. L.; Toth, K. S.; Handley, T. H. (Oak Ridge National Lab., Tenn.). Contract W-7405-eng-26. Phys. Rev., 163: 1291-4(Nov. 20, 1967). (ORNL-P-3140).**

Neutron-deficient holmium isotopes were produced by ^{156}Dy(p,xn) reactions. Chemical separations verified that the products were holmium nuclei; excitation-function determinations served to assign mass numbers to them. A new isotope, ^{154}Ho, was found to emit α particles of 3.91 ± 0.02 MeV with a half-life of 11.8 ± 1.0 min. A search was made for an α-decay transition from ^{155}Ho, but none was observed. The radionuclides ^{153}Ho and ^{152}Ho, already known to exist, were found to have respective α energies and half-lives that were 3.97 ± 0.02 MeV and 9.3 ± 0.5 min, and 4.37 ± 0.02 MeV and 2.7 ± 0.2 min. For ^{153}Ho, the α-decay-to-electron-capture ratio was measured to be 1.2 ± 0.7 × 10^{-3}. From a comparison with semiempirical estimates of α-decay rates, it was concluded that α transition of ^{153}Ho is not hindered. (auth)

3719 MEASUREMENT OF THE g_R FACTORS FOR THE FIRST EXCITED STATES OF ^{174}Yb AND ^{176}Yb USING THE MOESSBAUER EFFECT. **Eck, J. S.; Lee, Y. K.; Walker, J. C. (Johns Hopkins Univ., Baltimore). Phys. Rev., 163: 1295-8(Nov. 20, 1967).**

Using the Mössbauer effect following Coulomb excitation, the magnetic hyperfine interaction energies of the first excited states of ^{174}Yb and ^{176}Yb were measured. Metallic targets of Yb were used in conjunction with $YbCl_3 \cdot 6H_2O$ absorbers. Using the known value of the internal field in the absorber, the rotational gyromagnetic ratios for these states have been determined to be g_R^{174} = 0.338 ± 0.015, and g_R^{176} = 0.381 ± 0.018. Within the accuracy of the experiment, no isomer shift was detected in either case. The theoretical predictions, based on the collective model with pairing interaction, are used to interpret the present results and existing Mössbauer data on other isotopes of Yb. A better agreement can be obtained between the current theoretical and experimental values of the gyromagnetic ratios and moments of inertia of the even–even Yb isotopes if the energy-gap parameter used in the theoretical calculations is lowered by approximately 10%. (auth)

3720 ALPHA-PARTICLE EMISSION DURING NUCLEAR FISSION AT MODERATE EXCITATION ENERGIES. **Loveland, W. D.; Fairhall, A. W.; Halpern, I. (Univ. of Washington, Seattle). Contract AT(45-1)-1388. Phys. Rev., 163: 1315-22 (Nov. 20, 1967). (RLO-1388-24).**

Protons, deuterons, and helium ions of various energies up to 42 MeV were used to induce fission in thin targets of ^{232}Th, ^{235}U, ^{238}U, and ^{237}Np. α-particle emission during fission was detected by a system of solid-state detectors coupled to a coincidence-gated pulse-height analysis system. α particles emitted prior to fission were distinguished from fission-accompanied α particles by the tight angular correlation between α-particle and fission fragments which prevails in the latter case. It was found that the probability of α emission during fission is insensitive to excitation energy over the energy interval from about 5 to 38 MeV for a variety of heavy nuclei from thorium to plutonium. There is a suggestion that α-particle emission is fractionally more probable for spontaneous fission than for fission of the same nuclei excited to energies ≥ 5 MeV. α-particle emission in the fission of ^{213}At (^{209}Bi + 42 MeV α) was detected, the probability of α-accompanied fission being about ⅓ of that for a typical thorium or uranium nuclide. A possible effect of angular momentum on the probability of α emission during fission was looked for by forming ^{239}Pu in two different ways, the excitation energy being the same but the angular momentum being different. No significant effect was observed. A correlation between the energy of the α particles and the sharpness of their angular distribution relative to the fission fragments, which had been seen at lower energies, was observed here to hold as well at higher excitation energies. In an experiment to determine whether a correlation exists between the probability of α-particle emission and the mass ratio of the two heavy fission fragments, there is a suggestion that near-symmetric fragments have slightly less probability of emitting an α particle than asymmetric heavy fragments, although the effect is not very pronounced. (auth)

3721 EXCITED STATES OF ^{128}Xe. **Julian, Glenn M. (Lewis Research Center, Cleveland); Jha, S.; Johnston, A. S. Phys. Rev., 163: 1323-(Nov. 20, 1967).**

Gamma rays accompanying the decay of 25-min ^{128}I and 3-min ^{128}Cs were studied with 8- and 30-cc Ge(Li) spectrometers. Coincidences between γ rays were studied using two 7.6-cm × 7.6-cm NaI(Tl) scintillators. In the decay of ^{128}I, γ rays of the following energies were observed (relative intensities in parentheses): 443.3 (100.0), 526.4 (9.9), 743.3 (1.0), 969.7 (2.7), and 1139.9 (0.08) keV. In the decay of ^{128}Cs, γ rays of the following energies were observed (relative intensities in parentheses): 443.0 (100.0), 511.1 (414.0), 526.5 (7.3), 613.5 (0.93), 969.5 (1.6), 1030.8 (0.61), 1139.9 (4.0), 1304.9 (0.47), 1514.2 (0.14), 1631.0 (0.36), 1685.9 (0.32), 1981.9 (0.11), 2041.8 (0.074), 2157.2 (0.62), 2193.0 (0.13), 2277.8 (0.040), 2365.2 (0.15), 2398.2 (0.052), 2419.9 (0.082), 2592.4 (0.011), 2840.5 (0.011), and 2862.2 (0.016) keV. A level scheme for ^{128}Xe was constructed with levels at 443.2 (2^+), 969.6 (2^+), 1583.1 (0^+, 1^+, 2^+), 2275.2, 2484.3, 2600.5, 2841.1, and 2862.8 keV. The most important result of these studies is that no evidence was found for the existence of a 0^+ member of a possible two-phonon vibrational triplet. (auth)

3722 THE NUCLEAR g-FACTORS OF THE $\frac{5}{2}^-$[523] STATES IN ^{237}Np AND ^{239}Np AND THE LEVEL STRUCTURE OF ^{237}Np. **Gunther, Christian; Parsignault, Daniel R. (California Inst. of Tech., Pasadena). Contract (04-3)-63. Nucl. Phys., A104: 588-608(1967).**

The nuclear g-factors of the 59 keV level in ^{237}Np and the 75 keV level in ^{239}Np were measured by the α-γ perturbed angular correlation technique in a differential and integral measurement, respectively. Liquid sources were used to minimize perturbation by internal fields. The ratio of the g-factors is $g_{\frac{5}{2}}$-(^{239}Np)/$g_{\frac{5}{2}}$-(^{237}Np) = 1.04 ± 0.09. The Np ions are expected to be in the 6^+ valency state ($5f^1$). With a paramagnetic correction factor β estimated to be 1.68 ± 0.11, $g_{\frac{5}{2}}$-(^{237}Np) = 0.762 ± 0.060 and $g_{\frac{5}{2}}$-(^{239}Np) = 0.793 ± 0.097. The experimental values of the g-factors are in good agreement with the theoretical predictions of the Nilsson model. The γ-spectrum following the decay of ^{241}Am was studied with a Ge(Li) detector. The new results are discussed. (auth)

3723 NEUTRON RADIATIVE CAPTURE IN Mo. **Weigmann, H.; Schmid, H. (Euratom, Geel, Belg.). Nucl. Phys., A104: 513-24(1967).**

Neutron radiative capture in natural Mo was studied in the neutron energy range from 10 eV to 25 keV. An area analysis was applied to part of the observed resonances which yields $g\Gamma_n$ for small resonances or Γ_γ for large resonances. Above 1 keV neu-

tron energy, the observed capture rate was averaged to give the mean capture cross section which is in good agreement with earlier measurements. (auth)

3724 MAGNETIC MOMENT OF THE 660 keV STATE IN ^{117}In. Pandharipande, V. R.; Prasad, K. G.; Sharma, R. P. (Tata Inst. of Fundamental Research, Bombay). Nucl. Phys., A104: 525-8(1967).

The g-factor of the $^3/_2^+$ 660 keV state in ^{117}In was measured by the differential-delay, constant-angle method. The observed values of the g-factor and the magnetic moment are +0.63 ± 0.05 and +0.95 ± 0.08 μ_N, respectively. They are compared with the values predicted by the models for spherical and deformed nuclei. (auth)

3725 A STUDY OF THE DECAY OF 2.5 MIN ^{180}Re. Goudsmit, P. F. A.; Konijn, J.; de Boer, F. W. N. (Instituut voor Kernphysisch Onderzoek, Amsterdam). Nucl. Phys., A104: 497-510(1967).

The decay of 2.5 ± 0.1 min ^{180}Re was studied with several techniques. About 40 gamma rays were observed of which the following have an intensity larger than 0.5% per decay (energies in keV, intensities in parentheses): KX(87), 76.5(0.7), 103.8(23), 511(15.9), 742.2(0.7), 749.0(1.4), 824.9(11.8), 902.4(100), 1005.8(0.5), 1013.0 (1.2), 1116.0(0.7), 1129.3(0.6) and 1409.2(1.2). The end-point of the positon spectrum was measured as 1800 ± 60 keV leading to a total disintegration energy of ^{180}Re of Q^+ = 3828 ± 60 keV. The existence of levels is deduced at the following energies: 103.8 ± 0.4 keV (2^+), 338.6 ± 0.7 keV (4^+), 1006.2 ± 0.6 keV (2^-), 1755.2 ± 0.9 keV (1^+, 2^+ or 3^+) and 1831.3 ± 0.7 keV (2^-). The half-life of the 1006.2 keV level was measured as 7.4 ± 0.4 ns. The angular correlation between the 103.8 and 902.4 keV gamma rays was measured as $W(\theta) = 1 + (0.47 \pm 0.07)P_2(\cos\theta) + (-0.10 \pm 0.15)P_4(\cos\theta)$. Assignments are made in terms of the quasi-particle model. (auth)

3726 GAMMA-VIBRATIONAL STATES OF DEFORMED EVEN NUCLEI POPULATED IN THE (d,p) REACTION. Kern, Jean (Univ., Fribourg, Switzerland); Mikoshiba, Osamu; Sheline, Raymond K.; Udagawa, Takeshi; Yoshida, Shiro. Contract AT(40-1)-2434. Nucl. Phys., A104: 642-56(1967).

The spectroscopic factors for (d,p) excitation of gamma vibrational states in even deformed nuclei of the rare-earth region are calculated using the current microscopic description. The cross sections for populating these bands and also some two-quasi-particle bands are calculated and compared with experiment. Agreement is found to be fairly good. (auth)

3727 THE SPONTANEOUS FISSION HALF-LIFE OF ^{240}Pu. Fieldhouse, P.; Mather, D. S.; Culliford, E. R. (Atomic Weapons Research Establishment, Aldermaston, Eng.). J. Nucl. Energy, 21: 749-54(Oct. 1967).

A value for the spontaneous fission half-life of ^{240}Pu was obtained from the measured neutron emission rates of four relatively large ^{240}Pu neutron sources (~10^5 – 10^3 n/sec) and their known masses, compositions and multiplications. The four sources are the Aldermaston primary and two substandards, and the Harwell standard, all of which have been calibrated to an accuracy of better than 1 per cent. The "best value" of the average number of neutrons per fission, $\bar{\nu}$, for ^{240}Pu is discussed in arriving at a final mean half-life of 1.170 ± 0.025 × 10^{11} yr. The present determination is compared with other published measurements obtained by the more conventional technique of counting fission fragments from thin foils. (auth) (UK)

3728 ELECTRON CAPTURE RATIOS IN THE DECAY OF ^{105}Ag. Schulz, G.; Ziegler, K. (Univ., Heidelberg). Nucl. Phys., A104: 692-6(1967).

The ground state decay of ^{105}Ag was investigated with NaI(Tl) scintillation crystals containing ^{105}Ag as a constituent of the crystal lattice. The P_L/P_K electron capture ratios were measured for the transitions to the 1088 keV and to the 344 keV levels of ^{105}Pd. The results are: $(P_L/P_K)_{1088}$ = 0.152 ± 0.002 and $(P_L/P_K)_{344}$ = 0.128 ± 0.003. From these data were derived a mass difference between the ground states of the ^{105}Ag and the ^{105}Pd atom of 1300^{+50}_{-30} keV and an exchange correction of 1.10 ± 0.05. (auth)

3729 Ge(Li)–NaI(Tl) STUDIES OF THE DECAY OF ^{117}Te. Berzins, G. (Michigan State Univ., East Lansing); Kelly, W. H.; Graeffe, G.; Walters, W. B. Contract AT(30-1)-905. Nucl. Phys., A104: 241-62(1967). (MIT–905-95).

Results of independent investigations performed at MSU and MIT on the decay of 1.1 h ^{117}Te suggest an energy level scheme for ^{117}Sb. Sources were produced at MIT via the ^{114}Sn(α,n)^{117}Te reaction, while the MSU group bombarded natural antimony metal with 52 MeV protons. Ge(Li–NaI(Tl) coincidence experiments, γ-ray energy and relative intensity measurements, and positon end-point measurements were performed at both laboratories and produced results which were in excellent agreement. On the basis of these results, excited states in ^{117}Sb are placed at 719.7, 923.9, 1354.5, 1454.5, 1716.4, 1810.5, 2213, 2284.8, and 2300.0 keV. Additional levels, accommodating only very weak ground state transitions, may be present at 1596, 2380, and 2885 keV. No conclusive evidence for the existence of a possible ^{117m}Te was obtained. (auth)

3730 Ge(Li)-NaI(Tl) ANGULAR CORRELATION STUDIES OF GAMMA CASCADES IN THE DECAY OF ^{119m}Te. Berzins, G.; Kelly, W. H. (Michigan State Univ., East Lansing). Nucl. Phys., A104: 263-73(1967).

Angular correlation measurements were performed with a Ge(Li)-NaI(Tl) detector combination on several gamma-ray cascades present in the decay of 4.7 d ^{119m}Te. Results obtained for the 153–1213, 942–270, 1095–270, 976–979, 976–979–270, 2089–270, 1137–270, and 912–153–1213 keV cascades are in substantial agreement with previous spin assignments which were based primarily on conversion electron studies. Possible multipolarity mixing ratios are suggested for the 153, 270, 912, 942 and 1213 keV transitions. (auth)

3731 CONVERSION ELECTRON MEASUREMENTS OF TRANSITIONS FOLLOWING THE BETA DECAY OF ^{131m}Te. Beyer, L. M.; Kelly, W. H. (Michigan State Univ., East Lansing). Nucl. Phys., A104: 274-82(1967).

The MSU six gap orange and $\pi\sqrt{2}$, iron-free beta-ray spectrometers were used to study the internal conversion electron spectrum of ^{131m}Te. The multipolarities (in parentheses) of the 80.9 (M1), 102.3 (M1), 149.7 (90% M1, 10% E2), 200.7 (E1), 240.6 (E1), 334.5 (M1, E2), 452.7 (M1, E2) and 773.7 (80% E2 + 20% M1) keV transitions were determined. The E1 multipolarities of the 200.7 and 240.6 keV transitions and the log ft values of the beta decay to the high-energy states suggest negative-parity assignments for the 1797, 1899, and 1980 keV states in ^{131}I. In addition to the data presented, a survey of the low-energy, positive-parity states of the odd-mass iodine isotopes was performed. The energies of separation of several states were found to have a strong quadratic dependence on the neutron number. (auth)

3732 THE ^{128}Te(d,p)^{129}Te REACTION AT 7.5 MeV BOMBARDING ENERGY. Moore, W. H. (Massachusetts Inst. of Tech., Cambridge); Schlegel, G. K.; O'Dell, S.; Graue, A.; Lien, J. R. Contract AT(30-1)-2098. Nucl. Phys., A104: 327-39(1967).

The reaction ^{128}Te(d,p)^{129}Te has been studied at 7.5 MeV bombarding energy by using the MIT broad-range, multiple-gap magnetic spectrograph. A total of 87 levels of ^{129}Te has been identified below an excitation energy of 4.7 MeV. The angular distributions of the protons were analyzed in terms of zero-range, distorted-wave Born approximation calculations, and the orbital angular momentum of the transferred neutron was determined for 27 levels. Transition strengths were extracted and compared with pairing theory predictions. The ground-state wave function of ^{129}Te was found to be more complicated than expected from the simple shell model. (auth)

3733 QUADRUPOLE MOMENT OF THE $K^\pi = 0^+$ EXCITED STATE IN ODD ^{177}Lu. Jastrzebski, J. (Inst. of Nuclear Research, Warsaw); Moszynski, M.; Preibisz, Z.; Strycznicwicz, K.; Paris, P.; Treherne, J. Nucl. Phys., A104: 459-65(1967).

An investigation of ^{177}Hf ($T_{\frac{1}{2}}$ = 5y) decay was carried out after the sample was chromatographically purified of the daughter ^{177}Lu (6.5 d) isotope. The half-lives of the 110 keV (2^+) and 192 (1^+) states of ^{177}Lu were measured to be 2.30 ± 0.12 ns and ≲ 0.5 ns, respectively. The B(E2) of the 44 keV transition is calculated assuming the theoretical conversion coefficient α_T = 1.31. The value obtained for B(E2)↑ is (5.60 ± 0.28) × $10^{-48}e^2cm^4$. Assuming no band mixing, the intrinsic quadrupole moment of the $\{^7/_2^+[404]_p; ^7/_2^+[633]_n\}K = 0$ rotational band was deduced as Q_{22} = 7.50 ± 0.20 b. The γ-ray intensities measured with a Ge(Li) detector confirm the decay scheme of Valentin et al. and Harmatz and Handley. (auth)

3734 THE (^{3}He,d) REACTION ON ^{116}Sn, ^{118}Sn, AND ^{120}Sn. Ishimatsu, T.; Yagi, K.; Ohmura, H.; Nakajima, Y.; Nakagawa, T.; Orihara, H. (Tokyo Univ.). Nucl. Phys., A104: 481-96(1967).

The (^{3}He,d) reaction on ^{116}Sn, ^{118}Sn and ^{120}Sn was studied with 28.2 MeV ^{3}He particles. Deuteron spectra were measured with a broad-range magnetic spectrograph. Information on the nuclear structure of ^{117}Sb, ^{119}Sb and ^{121}Sb was obtained from the distorted-wave Born-approximation analysis of angular distributions of various deuteron groups. The $^{11}/_2^-$ state was located at 1.32, 1.37, and 1.42 MeV in ^{117}Sb, ^{119}Sb, and ^{121}Sb, respectively. The lowest lying $^5/_2^+$, $^1/_2^+$, and $^{11}/_2^-$ states in each of the three nuclei were found to be of rather pure single-particle character, whereas the lowest lying $^1/_2^+$ and $^3/_2^+$ states are found to be seriously mixed. (auth)

3735 NUCLEAR DATA. SECTION B, VOLUME 2, NUMBER 1, JULY 1967. Nucl. Data, Sect. B, 2: No. 1, B2-1-i-117(July 1967).

A compilation of evaluated data is presented on energy-level schemes and transitions, decay properties, and various reaction Q-values for nuclei in the mass range A = 142 to 145. (S.F.L.)

3736 ON THE EFFECT OF THE PAULI PRINCIPLE ON THE COLLECTIVE OSCILLATIONS IN SPHERICAL EVEN NUCLEI. Miyanishi, Yoshinao; Yamamura, Masatoshi (Univ., Kyoto). Progr. Theor. Phys. (Kyoto), 38: 332-52(Aug. 1967).

With the purpose of clarifying the effect of the Pauli principle on the collective oscillations in spherical even nuclei, the method which enables one to take into account one of the effects of the Pauli principle, the blocking effect, is developed in the framework of the "ideal boson" picture. The method developed is, in some sense, the refined treatment of the method proposed by Ikeda, Udagawa and Yamaura and independently by Hara. By taking account of this effect, agreement with the experimental facts becomes very good compared with the calculation based on the conventional random phase approximation. (auth)

3737 PROPERTIES OF PLUTONIUM ISOTOPES. Leonard, B. R. Jr. (Battelle-Northwest, Richland, Wash.). pp 1-8 of Plutonium Handbook. A Guide to the Technology. Vol. I. Wick, O. J. (ed.). New York, Gordon and Breach Science Publishers, 1967.

The general behavior of Pu in reactor systems and the important microscopic properties of Pu isotopes are considered. These are discussed under the following headings: initial production of Pu, production of Pu in nuclear reactors, effects of Pu content on reactor behavior, and neutron irradiation of Pu. This is followed by a summary of the isotopic properties that are important in the identification, handling, and analysis of Pu. The nuclear properties of Pu are discussed under the following headings: relative nuclidic masses, the excited state of Pu nuclei, β-unstable isotopes, α decay, and spontaneous fission. (B.L.M.)

3738 NUCLEAR REACTIONS. Leonard, B. R. Jr. (Battelle-Northwest, Richland, Wash.). pp 9-30 of Plutonium Handbook. A Guide to the Technology. Vol. I. Wick, O. J. (ed.). New York, Gordon and Breach Science Publishers, 1967.

The more important features of neutron-induced reactions of the Pu isotopes are presented, with references to tabulations of detailed data. (S.F.L.)

3739 ELECTRON–GAMMA DIRECTIONAL CORRELATION MEASUREMENTS IN HEAVY NUCLEI. Meder, Martin Robert. New Orleans, Tulane Univ., 1966. 83p.

Thesis.

Using a 3 in. × 3 in. and a 2 in. × 1.75 in. NaI(Tl) crystal as γ-ray detectors and a cooled Si(Li) crystal as the electron detector, both $\gamma-\gamma$ and $e^-\gamma$ directional correlations were measured in ^{133}Cs, ^{177}Hf, and ^{206}Pb. The following directional correlation coefficients were obtained after correction for finite solid angles and chance coincidences (transition energies in KeV). ^{133}Cs: 356γ–81γ, $A_2 = 0.038 \pm .003$, $A_4 = 0.002 \pm .018$; 356(K) – 81γ, $A_2 = 0.064 \pm 0.006$, $A_4 = 0.006 \pm 0.021$; 356(TL) – 81γ, $A_2 = 0.050 \pm .021$, $A_4 = 0.001 \pm 0.036$; 356γ – 81(LM), $A_2 = 0.013 \pm 0.007$, $A_4 = 0.016 \pm 0.024$; 276γ – 161γ, $A_2 = -.415 \pm 0.014$, $A_4 = -0.020 \pm 0.020$; 267γ – 161K, $A_2 = -0.210 \pm 0.019$, $A_4 = -0.072 \pm 0.021$; 276γ – 161L, $A_2 = -0.182 \pm 0.026$; $A_4 = -0.035 \pm 0.018$. ^{177}Hf: 208γ – 113γ, $A_2 = -172 \pm .016$; 208K – 113γ, $A_2 = 0.291 \pm 0.010$; 208LM – 113γ, $A_2 = 0.243 \pm 0.016$; 208γ – 113K, $A_2 = 0.025 \pm 0.014$; 208γ – 113K, $A_2 = 0.014 \pm 0.008$; 208γ – 113LM, $A_2 = 0.004 \pm 0.050$. ^{206}Pb: 512γ + 538γ – 343γ, $A_2 = -0.067 \pm 0.036$, $A_4 = 0.334 \pm 0.047$; 512γ + 538γ – 343K, $A_2 = -0.002 \pm 0.083$, $A_4 = 0.014 \pm 0.009$; 512γ + 538γ – 343L, $A_2 = 0.007 \pm .023$, $A_4 = 0.044 \pm 0.023$; 497γ – 398K, $A_2 = 0.012 \pm 0.017$, $A_4 = 0.089 \pm 0.027$. It was found that particle parameters calculated from the point-nucleus approximation are quite accurate in pure transitions. The L-shell particle parameters calculated on the finite size surface current model were found to be accurate in pure transitions. (Disser. Abstr.)

3740 BETA–GAMMA DIRECTIONAL CORRELATION MEASUREMENTS AND ANALYSIS FOR SOME ANOMALOUS BETA TRANSITIONS. Cantrell, Bruce Keith. Bloomington, Ind., Indiana Univ., 1966. 112p.

Thesis.

The energy dependence of the beta-gamma directional correlation was measured for the 1.5-MeV anomalous allowed decay of ^{56}Co and the 2.3-MeV first-forbidden transition of ^{124}Sb. The measurement was done using a shaped field magnetic spectrometer. For ^{56}Co, over an energy range of 0.5 to 1.4 MeV, ϵ varied from 0.006 ± 0.007 to 0.039 ± 0.016. To contrast this with a zero directional correlation measurement using the same apparatus, a recent measurement of the 0.49-MeV transition in ^{58}Co is also reported as $\bar{\epsilon} = 0.025 \pm 0.0046$. The measurement for ^{124}Sb over the energy range of 1.0 to 2.1 MeV gave a directional correlation of $\epsilon = -0.22 \pm .02$ to -0.40 ± 0.01. To determine empirical values for the nuclear matrix elements associated with these decays, a general analysis scheme using a chi-square minimization was developed. Generally, the analysis compares the experimental data with the theoretically derived values of the observable for the shape, beta-gamma directional correlation, and the beta-(circularly polarized) gamma angular correlation. In all cases, the actual shape data was used to form the chi-square. This analysis was also applied to the anomalous allowed decay of ^{22}Na and anomalous first-forbidden transitions in ^{152}Eu, ^{154}Eu, ^{140}La, ^{72}Ga, ^{185}Re, ^{86}Rb and ^{84}Rb. For the allowed decays, the analysis was done using only "exact" evaluations for the electron wave functions used in the expressions for the observables. Also, only contributions from the relativistic matrix elements were considered in the formalism for these decays. In the case of the first-forbidden transitions, two analyses were carried through using electron wave functions which were corrected "exact" and uncorrected for the finite nuclear size. In this way, it was hoped to determine directly what effect correcting for the finite nuclear size has on the results of the analysis of the decays. It was found that the V-A formalism including relativistic correction terms is quite adequate for the description of the allowed decays considered when exact electron wave functions are used in the analysis. Specific results for ^{56}Co and ^{22}Na indicate a suppression of the normal allowed matrix elements relative to the second-forbidden corrections. In the case of ^{56}Co, the angular distribution from polarized nuclei was used to differentiate among the matrix element sets found for the decay. In this way, a set of matrix elements was determined to within a sign that is consistent with all the experimental information. For ^{22}Na, only one set of matrix elements was obtained. It was also found that making a correction for the finite nuclear size seems to have little or no effect on the outcome of the analysis of the first-forbidden decays considered. For ^{124}Sb, the results of the analysis indicate a suppression of the normal first-forbidden matrix elements and dominance of the unique B_{ij} terms indicating a possible selection rule effect in the decay. For this decay the suggestion is made that a measurement of the circular polarization correlation as a function of energy may be sufficient to distinguish between the two sets of matrix elements obtained. (Disser. Abstr.)

3741 ENVIRONMENTAL EFFECTS ON THE DECAY CONSTANT OF ^{90m}Nb. Cooper, John Arthur. Berkeley, Calif., Univ. of California, 1966. 147p.

Thesis.

A new method was developed to study changes in nuclear decay constants due to alterations in the chemical or physical environment. This method was applied to the study of the effect of chemical state changes, the effect of a large increase in pressure and the effect of changes into and out of the superconducting state on the decay constant of the 24-second isomeric state in ^{90}Nb. The following results were obtained for these environmental changes: λ(Aqueous Fluoride) – λ(Metal) = $(-0.036 \pm 0.004)\lambda$(Aqueous Fluoride); λ(100,000 atm) – λ(1 atm) = $(0.006 \pm 0.007)\lambda$(100,000 atm); λ(12°K) – λ(4.2°K, superconducting) < 0.002 λ(12°K). These results show that the energy of the transition depopulating this isomeric state is very low and that an appreciable fraction of the isomeric decay takes place by ejection of valence electrons. The gamma-ray spectrum of ^{90}Mo was also investigated. Several new lines were observed and the photon intensities were measured. The multipolarities of many of the intense transitions were determined and their coincidence relations resolved with gamma-gamma coincidence studies. A decay scheme was postulated from which the energy of the transition depopulating the 24-sec isomeric state was determined from energy differences to be 2.38 ± 0.36 keV. (Disser. Abstr.)

3742 THE MASS SPECTROMETRIC DETERMINATION OF THE THERMAL NEUTRON CROSS SECTION OF ^{147}Sm, USING ENRICHED RARE EARTH ISOTOPES AS A NEUTRON TEMPERATURE MONITOR. Forman, Leon. Troy, N. Y., Rensselaer Polytechnic Inst., 1966. 122p.

Thesis.

The thermal neutron cross section of ^{147}Sm was measured by the mass spectrometric determination of ^{148}Sm atoms formed by neutron capture. Isotopically pure samples were irradiated in a well thermalized neutron spectrum for which the integral neutron flux and effective neutron temperature were monitored by comparing the neutron burnup in ^{149}Sm and ^{157}Gd. A ^{147}Sm thermal neutron cross section of 75 ± 11 barns was obtained at an effective neutron temperature of 127°C. Isotopic enrichment and post-irradiation analysis of samples were accomplished by means of a four-stage mass spectrometer. This instrument consists of two 20-inch radius of curvature magnetic lenses, and two 20-inch radius of curvature electrostatic analyzers, arranged in a symmetrical manner such that two complete double-focusing systems are in tandem. The development of this spectrometer comprised a sig-

nificant portion of this research. Small samples (~10^{12} atoms as monitored by ion beam current measurements) were collected at the final focal point of the spectrometer on rhenium ribbon filaments. After irradiation, these filaments served as the mass spectrometer surface ionization source. Improved non-1/v factors for ^{157}Gd were calculated from recent energy-dependent total cross section measurements. The ^{157}Gd results were used with Westcott's non-1/v parameters for ^{149}Sm to normalize the integral flux and effective neutron temperature data. The samples were irradiated in the graphite reflector region of the D_2O moderated Argonne CP-5 reactor. The epithermal index in this region of the reactor is less than 0.002. The measured ^{148}Sm/^{147}Sm ratio after irradiation was 0.00025 ± 0.00002. This corresponds to a ^{147}Sm cross section measurement of 75 ± 11 barns, a value which lies well within the 87 ± 60 barn measurement of Jowitt et al. It should be noted that less than 2×10^9 atoms of ^{148}Sm were formed during the neutron irradiation. Nevertheless, this minute amount was analyzable by advanced mass spectrometric techniques. In addition, methods developed in this work have circumvented the need for all sample chemistry in cross section measurements, and have eliminated the application of self-shielding corrections. Many improved integral measurements should be possible by the application of methods developed in this investigation. (Disser. Abstr.)

3743 FAST-NEUTRON ACTIVATION ACROSS SECTIONS FOR ^{23}Na, ^{55}Mn, ^{115}In, AND ^{165}Ho. Menlove, Howard Olsen. Stanford, Calif., Stanford Univ., 1966. 131p.

Thesis.

Activation cross sections for the ^{23}Na(n,γ)^{24}Na, ^{55}Mn(n,γ)^{56}Mn, ^{115}In(n,γ)$^{116\,m}$In, and ^{165}Ho(n,γ)^{166}Ho reactions were measured by activation techniques at 17 neutron energies between approximately 1.0 and 19.5 MeV. Neutrons were produced by means of the T(p,n)^{3}He, D(d,n)^{3}He, ^{9}Be(α,n)^{12}C, and T(d,n)^{4}He reactions using a 3.5-MeV Van de Graaff accelerator. The measurements were made relative to the fission cross section of ^{235}U for fast neutrons. A thermal-neutron irradiation in a reactor was made in order to obtain cross sections normalized to the thermal activation cross sections of the irradiated samples and the thermal fission cross section of ^{235}U. The experimental cross-section data show evidence of a peak in the vicinity of 14 MeV. The radiative capture cross sections which were measured in this experiment were compared with the cross sections predicted by the "direct capture" reaction theory of Lane and Lynn and the "semi-direct capture" reaction theory of Brown. Qualitative agreement with the latter theory is demonstrated. In conjunction with the (n,γ) cross section measurements, the (n,2n) activation cross sections of ^{19}F, ^{23}Na, ^{55}Mn, ^{115}In, and ^{165}Ho were measured in the neutron energy range from 12.7 to 19.5 MeV. Also the activation cross sections for the ^{115}In(n,n′)$^{115\,m}$In and ^{27}Al(n,α)^{24}Na reactions were measured in the energy range from 1 to 19.5 MeV and from 6 to 19.5 MeV, respectively. These particular nuclides were measured since they were all activated in conjunction with the (n,γ) cross section measurements previously mentioned. Absolute gamma-counting techniques were used to determine the number of interactions occurring during the neutron irradiation. The cross sections of the samples were measured relative to the fission cross section of ^{235}U. The half-life of ^{164}Ho was found to be 38.8 ± 1 min. The (n,2n) cross section measurements from the present experiment were compared with the semi-empirical cross section theories of Pearlstein and Gardner. The agreement of the measurements with the calculated (n,2n) cross sections is good up to the (n,3n) threshold energy where the calculated cross sections drop below the measured cross sections. (Disser. Abstr.)

3744 THE AUGER, INTERNAL CONVERSION, AND GAMMA-RAY SPECTRA FROM THE DECAY OF ^{233}Pa AND AN INVESTIGATION OF THE EFFECT OF PHOTOELECTRON SCATTERING ON THE IEC METHOD. Zender, Michael Joseph. Nashville, Vanderbilt Univ., 1966. 148p.

Thesis.

An attempt was made to provide some much needed experimental measurements of very low energy L-Auger and L-Coster-Kronig transitions and to resolve discrepancies which have existed between previous experimental measurements of ^{233}U internal conversion coefficients and theory. In addition, the new theoretical scattering corrections for the IEC f factor were investigated experimentally at low energies as a function of converter thickness; and the electron "focusing effect" of the Vanderbilt post-accelerator Geiger counter was eliminated. The low-energy (less than 9 keV) electron focusing properties of the post-accelerating detector were deduced by calculation and verified experimentally by photographing the incident electron beam. The effect was eliminated by an appropriate lateral displacement of the counter slit and the detector was then used to measure the relative intensities of the ^{233}U L-Auger and L-Coster-Kronig electron lines (0.5 to 18 keV). The total ^{233}U L-shell fluorescent yield was measured as $\omega_L = 0.53$ in good agreement with the work of other authors. The higher energy KLL-Auger spectrum was also investigated. The energies and relative intensities of the KLL lines were in good agreement with the semi-empirical energy calculations of Hörnfeldt and the theoretical relative intensities of Listengarten. The K, L and M conversion coefficients were measured for most of the transitions in ^{233}U. The conversion coefficients were obtained by measuring the internal conversion electron spectrum with the Vanderbilt iron-free, double-focusing, beta spectrometer and the gamma-ray spectrum with a 3-mm depletion depth Li-Ge detector located at Oak Ridge National Laboratory. The two sets of measurements were then normalized by means of the measured value (IEC) of the K conversion coefficient of the 312-keV transition (0.70). The conversion coefficients of several transitions were also measured by means of the IEC method (silver converters). The conversion coefficient of the 312-keV transition as measured by the IEC method was 0.70 ± 0.05. Measurements of conversion coefficients by means of uranium converters were uncertain because of possible scattering effects (see below). In general, the experimental conversion coefficients were in much better agreement with the theoretical values of Sliv and Band than with the theoretical values of Rose. The effect of photoelectron scattering on the f factor used in the IEC method was studied for uranium converters (0.43 to 3.71 mg/cm^2) in the 300- to 400-keV range by measuring the intensity of the external conversion (photoelectron) line (A_{ex}) as a function of converter thickness, d_o (mg/cm^2). The quantity $(A_{ex})_K/d_o$, which should be directly proportional to f for a particular transition, was then plotted as a function of d_o for the 312- and 340-keV transitions in ^{233}U, the 364-keV transition in ^{131}Xe and the 412-keV transition in ^{198}Hg. The resultant curves exhibited a pronounced maximum at d_o = 2.19 mg/cm^2 in contrast to the monotonic decline with d_o predicted by Hultberg in new scatter-corrected f factor calculations. The known conversion coefficients of the 364- and the 412-keV transitions, 0.0196 and 0.030, respectively, were used to measure the absolute value of f at these two energies and the experimental f factor for the 2.19 and 3.71 mg/cm^2 converters were found to be more than 20% higher than Hultberg's theoretical values for the particular source-converter geometry used. The experimental and theoretical f factors were in approximate agreement for the thinnest converter used, d_o = 0.43 mg/cm^2. Thus, both the functional dependence and the absolute value of the experimental f factor are found to differ from theory. The discrepancy observed here requires immediate experimental and theoretical investigation if high Z converters are to be used in the 300- to 400-keV energy range. (Disser. Abstr.)

Nuclear Theory

Refer also to abstracts 3221, 3289, 3351, 3464, 3574, 3588, 3608, 3616, 3628, 3632, 3658, 3670, 3672, 3675, 3682, 3684, 3707, 3712, 3726, and 3869.

3745 (ANL-7306) PROGRAMS FOR ANALYSIS OF SCATTERING ANGULAR DISTRIBUTIONS. Pennington, E. M.; Gajniak, J. C.; Mewaldt, R. A. (Argonne National Lab., Ill.). May 1967. Contract W-31-109-eng-38. 71p. Dep. CFSTI.

FORTRAN programs written to aid in the analysis of neutron elastic scattering angular distributions are described. The SAD program consists of subroutines used to obtain Legendre expansion coefficients by least-squares fitting of input angular data, to produce Calcomp plots of angular distribution data, to transform expansion coefficients from the laboratory system to the center-of-mass system, and to change the normalization of the expansion coefficients. Another program, DRIVER, plots expansion coefficients as a function of energy. (auth)

3746 (BNL-11746) NUCLEAR MAGNETIC AND ELECTRIC MOMENTS. Cohen, Victor W. (Brookhaven National Lab., Upton, N. Y.). Sept. 14, 1967. 21p. (CONF-671042-1). Dep. CFSTI.

From German Physical Society, Berlin, Germany.

A brief review of the interactions and measurement of nuclear moments is presented. The nuclear quantities that can be determined using optical double resonance, paramagnetic resonance, nuclear magnetic resonance, optical hyperfine structure, and particularly, atomic beam magnetic resonance are discussed. Experiments for determining the electric dipole moments of the Ca atom and the neutron are also outlined. (D.C.W.)

3747 (CONF-660306-31) ISOBARIC SPIN AND ANALOG SPIN. Technical Report 555. MacDonald, W. M. (Maryland Univ., College Park. Dept. of Physics and Astronomy). Mar. 1966. 19p. Dep. CFSTI.

From American Physical Society, Conference on Isobaric Spin, Tallahassee.

It is shown that, to a great extent, the distortions which are introduced into nuclear wave functions by the Coulomb interaction can be included in a wave function that possesses a more general symmetry than the usual isobaric spin states. These wave functions are obtained from a generalization of isobaric spin which is called "analog spin." The significance of the name is that the corresponding states which were recently discovered in heavy nuclei and are called analog states are actually eigenfunctions of the analog spin quantum number. (D.C.W.)

3748 (INP-545/PL) WYLICZANIE ROZNICZKOWEGO PRZEKROJU CZYNNEGO NA REAKCJE WYBICIA (PRZYBLIZENIE FAL PLASKICH WEDLUG METODY W. TOBOCMANA). PROGRAM DLA MASZYNY CYFROWEJ UMC-1. (Computation of the Differential Cross-Section for Knock-Out Reaction (Plane Waves Approximation According to W. Tobocman Method). The Program for the Computer UMC-1). Makowska-Rzeszutko, M. (Institute of Nuclear Physics, Krakow (Poland)). May 1967. 38p. (In Polish). Dep.

A formula and a program for computing the differential cross section for the $^{12}C(d,\alpha)^{10}B$ reaction, according to W. T. Tobocman's method, are presented. A description and an example of practical application of the program are included. (auth)

3749 (INP-555/PL/PH, pp 137-45) PROSTAYA MIKROSKOPICHESKAYA MODEL' ATOMNOGO YADRA. (Simple Microscopic Model of Atomic Nuclei). Kirzhnits, D. A. (Akademiya Nauk SSSR, Moscow. Institut Fiziki). (In Russian).

A microscopic model based on an empirical pair potential of interactions of isolated nucleons is described. The model does not contain any arbitrary phenomenological parameters. The model describes nucleon interactions in nuclear matter. (R.V.J.)

3750 (INP-555/PL/PH, pp 123-4) ONE-PARTICLE ASPECTS OF THE FISSION PROCESS. Szymanski, Z.; Wycech, S. (Institute of Nuclear Research, Warsaw (Poland)).

The assumption of individual nucleon motion in an average nuclear potential is used for the calculation of the nuclear fission properties. Preliminary calculations of the nuclear effective inertial parameter and the saddle-point deformation are reported. (L.B.S.)

3751 (INP-555/PL/PH, pp 125-36) ANHARMONIC EFFECTS AND APPEARANCE OF THE NUCLEAR DEFORMATION IN EVEN-EVEN NUCLEI. Jolos, R. V. (Joint Inst. for Nuclear Research, Dubna (USSR)).

A method is presented for finding the energy of even-even nuclei as a function of the deformation parameters. It is found that the potential energy of the nuclear deformation is a bounded function of the deformation parameters, which is in contrast to the frequently used harmonic potential. The potential energy of the deformation has two minima, in agreement with the phenomenological model of Myers and Swiatecki. (S.F.L.)

3752 (INP-555/PL/PH, pp 147-53) RESIDUAL INTERACTION IN NUCLEI. Bochnacki, Z. (Institute of Nuclear Physics, Krakow (Poland)).

A brief review is given of the role and forms of the residual, or effective interaction operator used in nuclear spectroscopic calculations. A discussion is given of the fundamental many-body approach to the finite nucleus problem in which the shell-model potential and effective-interaction operators are determined by the free-nucleon interaction, rather than using a more phenomenological approach. (S.F.L.)

3753 (INP-555/PL/PH, pp 155-61) ISOBARIC ANALOGUE RESONANCES IN HEAVY NUCLEI AND COULOMB DISPLACEMENT ENERGIES. Marquardt, N. (Max-Planck-Institut fuer Kernphysik, Heidelberg (West Germany)).

It is shown that an isobaric analog state can be represented as a superposition of scattering states and two-particle one-hole states. A fit of the excitation function at 170° for proton elastic scattering on ^{140}Ce is obtained for $E_p = 8$ to 12 MeV. By fitting measured Coulomb displacement energies a linear relation of the form $\Delta E_{Coul.} = a(ZA^{-b}) - b$ was found, with a and b constants. Using this expression and a semiempirical formula derived by Swamy and Green, the nuclear radius parameter r_0 was derived as a function of A. A number of these r_0 values obtained by the excitation of isobaric analog resonances are given. These are compared with results of electron scattering and μ-mesonic X-ray experiments which were fitted on the assumption of a Fermi charge distribution. (S.F.L.)

3754 (INP-555/PL/PH, pp 163-5) NEUTRON-NEUTRON-HOLE STATES IN ^{140}Ce. Heusler, A. (Max-Planck-Institut fuer Kernphysik, Heidelberg (West Germany)).

The well-isolated resonances in ^{141}Pr which are isobaric analog to low-lying states in ^{141}Ce contain few but strong inelastic proton partial widths into neutron-neutron-hole states in ^{140}Ce. A formula is given which reproduces the differential cross section very well. (S.F.L.)

3755 (PUC-937-169) FIRST AND SECOND ORDER CORRECTIONS TO THE MAGNETIC MOMENTS OF NUCLEI USING REALISTIC INTERACTIONS. Mavromatis, H. A.; Zamick, Larry; Brown, G. E. (Princeton Univ., N. J. Palmer Physical Lab.). July 1965. 34p. Dep. CFSTI.

First- and second-order corrections to the magnetic moments of nuclei near closed shells are calculated using the semi-realistic hard core Kallio Kolltveit interaction. While configurational admixture to first, second, or higher orders in perturbation theory is not the sole agency producing corrections to the Schmidt values, for most nuclei it accounts for much of the inward deviation from the Schmidt lines. For nuclei like ^{17}O, ^{41}Ca where there is no first-order correction to the magnetic moment configurational admixture and second-order perturbation theory must be included in an analysis of the experimental deviation. It is found that for ^{17}O the second-order effect is too large, and another mechanism working in the opposite direction is required, while for ^{41}Ca the second-order effect accounts for the experimental deviation. (auth)

3756 (TID-24142) 1967 YUGOSLAV SUMMER SCHOOL LECTURE NOTES ON HARTREE-FOCK THEORY. Levinson, Carl A. (Maryland Univ., College Park). [1967]. Contract AT(40-1)-3491. 21p. Dep. CFSTI.

The nuclear Hartree-Fock approximation is reviewed with emphasis on the calculation of the single-body Hamiltonian in terms of a given two-body potential. (D.C.W.)

3757 (TID-24143) FINE STRUCTURE IN NUCLEAR RESONANCES. Technical Report 653. MacDonald, W.; Mekjian, A. (Maryland Univ., College Park. Dept. of Physics and Astronomy). Jan. 1967. Contract AT(40-1)-3491. 35p. Dep. CFSTI.

A K-matrix formulation is given for the shell-model approach to a unified reaction theory. This K-matrix differs from the R-matrix of Wigner and Eisenbud in using distorted waves of a diffuse potential. The penetrabilities and channel phase shifts are therefore those for a diffuse potential rather than those for a square well with hard-sphere boundary conditions at some radius. This K-matrix is used to discuss the fine structure produced by a doorway-hallway system, and a result obtained earlier by Ferrell and MacDonald is rederived. A resonance expansion is then found which explicitly exhibits the widths and resonance energies in a multilevel formula. The distribution of the widths is found, a sum rule is derived. The average cross section is also derived. A general resonance formula is then derived for the case of any number of hallway and doorway states. This is used to generalize the previously obtained doorway-hallway results to the case of hallways coupled to the continuum. A characteristic asymmetry is shown to result in certain cases. (auth)

3758 USE OF THE K MATRIX IN NUCLEAR REACTION THEORIES. Tobocman, W.; Nagarajan, M. A. (Case Western Reserve Univ., Cleveland). Phys. Rev., 163: 1011-16(Nov. 20, 1967).

Two recent formulations of nuclear reaction theory have been based on the reactance operator K. Expressions given in these formulations for the reactance operator are identical in form with those that hold for the transition operator T, except that the scattering Green's function is replaced by the standing-wave Green's function. Formal scattering theory was used to find the formal solutions to the Lippmann-Schwinger equations for K and T. It was found that the solution for K differs from that used in these formulations. The discrepancy appears to be significant for one of the formulations but not for the other. (auth)

3759 GROUP CLASSIFICATION OF MANY-BODY INTERACTIONS. Vincent, C. M. (Univ. of Witwatersrand, Johannesburg). Phys. Rev., 163: 1044-50(Nov. 20, 1967).

For an n-fermion system in which each particle can occupy any one of k states, an "irreducible b-body operator" is defined as an operator belonging to $[2^b,1^{k-2b}]$ of SU_k. It is shown that such an operator can always be written as a b-body operator multiplied by a function of n. A measure of the failure of a basis to diagonalize the Hamiltonian is constructed. If the Hamiltonian is analyzed into irreducible b-body parts, the measure of error for n particles can be calculated from two-particle parameters. An upper limit on the error of a group theoretically defined basis can be found without having to calculate any n-particle interaction matrix elements. A measure of the magnitude of an interaction is defined and is shown to depend differently on n for irreducible 0-body, 1-body, and 2-body interactions. The effect of the Pauli principle on the forma-

tion of shell-model potentials is discussed from this point of view. (auth)

3760 ANGULAR MOMENTUM DEPENDENCE OF OFF-SHELL AMPLITUDES. Kowalski, K. L. (Case Western Reserve Univ., Cleveland). Phys. Rev., 163: 1030-1(Nov. 20, 1967).

The decrease of off-shell partial-wave amplitudes with increasing orbital angular momentum is investigated. A simple bound which is independent of the parametric energy is found which shows the same l behavior as the on-shell amplitudes corresponding to the external momenta. (auth)

3761 ROLE OF PERTURBED ANGULAR CORRELATIONS IN SYMMETRY TESTS. Lewis, R. R. (Univ. of Michigan, Ann Arbor). Phys. Rev., 163: 935-47(Nov. 20, 1967).

The most familiar "rules" for testing the invariance of nuclear electromagnetic transitions under space and time inversions are based on the theory of unperturbed angular correlations. It is shown that the perturbation of an angular correlation can increase the efficiency of such experiments by removing the need for using polarized particles. An external field can reorient the spin of the intermediate state, changing an alignment into a polarization. The theory of such "off-diagonal" perturbations is discussed, with attention to two specific models: electric quadrupole interaction with an axially symmetric electric field gradient, and magnetic dipole interaction with external and internal magnetic fields. The quadrupole interactions are found to be very efficient in producing nuclear orientation of odd rank. A survey of possible applications of these results is given, with emphasis on the decay of ^{181}Ta. (auth)

3762 GENERALIZED HELM MODEL FOR TRANSVERSE ELECTROEXCITATION OF NUCLEAR LEVELS. Rosen, M. (Naval Research Lab., Washington, D. C.); Raphael, R.; Uberall, H. Phys. Rev., 163: 927-34(Nov. 20, 1967).

Helm's model for nuclear transition charge densities, assuming these to extend over a smeared-out shell at the nuclear radius, has been found useful in describing Coulomb-type electroexcitation of individual nuclear levels. The model was extended by obtaining corresponding nuclear transition current densities (satisfying the continuity equation) and magnetization densities, which permit calculation of transverse matrix elements, and hence offer a description of electroexcitation of single levels at large electron scattering angles. The model yields a good numerical fit to the 15.1-MeV level in ^{12}C and to other examples. In addition, the relation between the M, T and the B notation for electroexcitation matrix elements is established and the Isabelle-Bishop expansion in powers of the momentum transfer is rederived. (auth)

3763 ON THE HIGHEST PENETRABILITY OF THE COULOMB BARRIER IN ALPHA DECAY. Ixaru, Liviu (Inst. of Atomic Physics, Bucharest). Rev. Roum. Phys., 12: 589-602 (1967).

The contribution of the alpha particle structure on the Coulomb barrier in alpha decay is studied. An emission model based on the idea that the emitted alpha particle has "frozen" angular degrees of freedom is introduced. This model leads to an expression for the penetrability that is in better agreement with the experimental data. The numberical results are larger by a factor of 20 than those obtained by Rassmusen. (auth)

3764 REDUCED ALPHA TRANSFER AMPLITUDES WITH RASSEY WAVE FUNCTIONS. Cioaca, C. (Bucharest Univ.); Dumitrescu, O.; Sandulescu, A. Rev. Roum. Phys., 12: 619-22(1967).

A method that permits more rapid evaluation of the reduced alpha amplitudes associated with nucleon transfer from orbitals is outlined. (D.C.W.)

3765 THEORY OF (^{3}H,d) REACTIONS. Abou-Hadid, L. F.; El-Hamaki, B. (Tarik El-Horria- Rochdi, Alexandria, Egypt). Nuovo Cim. (10), 51B: 514-24(Oct. 11, 1967).

The differential cross section of the reaction $^AX(^3H,d)^{A+1}X$ is obtained off and near a resonance level. (auth)

3766 APPROXIMATION OF BOSONS AND ANTISYMMETRY. Simard, P. A. (Laval Univ., Quebec). Can. J. Phys., 45: 3241-6(Oct. 1967). (In French).

A method is presented in the scheme of the boson approximation such that the antisymmetry between the quasiparticles is introduced naturally. Based on the transcription of the quasiparticle into the ideal space, the method enables one to give a unified description of the anharmonic corrections in the even-even and odd spherical nuclei. (auth) (Canada)

3767 ADJUSTMENT OF RELATIVE ATOMIC MASSES. Mattauch, J. H. E. (Max-Planck-Institut fuer Chemie, Mainz); Thiele, W.; Wapstra, A. H. Nucl. Phys., 67: 73-120(1965).

An extensive computer program was written for, and applied to, the calculation of "best values" for the masses of atoms from measured values of mass spectroscopic doublets and those of nuclear reaction energies. The program also serves for the calculation of reaction and decay energies derived from these best values. The experimental input data are tabulated, discussed, and compared with the adjusted values. (auth)

3768 CONSISTENT SET OF Q-VALUES. Mattauch, J. H. E. (Max-Planck-Institut fuer Chemie, Mainz); Thiele, W.; Wapstra, A. H. Nucl. Phys., 67: 32-72(1965).

A list of alpha decay energies, binding energies of some combinations of protons and neutrons, and reaction energies of various nuclear reactions for a large number of nuclides are derived by least squares adjustment of a large set of experimental data. (auth)

3769 1964 ATOMIC MASS TABLE. Mattauch, J. H. E. (Max-Planck-Institut fuer Chemie, Mainz); Thiele, W.; Wapstra, A. H. Nucl. Phys., 67: 1-31(1965).

The derivation of a new mass table from experimental data is outlined, and the revised table is presented. Masses that were derived from estimated α or β decay energies are included. Mass excesses in energy and mass units, total binding energies, and β decay energies are given. (D.C.W.)

3770 ON THE DETERMINATION OF K-CONVERSION COEFFICIENTS. Sahota, H. S.; Sood, B. S. (Punjab Univ., Patiala, India). Curr. Sci. (India), 36: 601-2(Nov. 20, 1967).

A method for determining K-conversion coefficients from measurements of the K x-ray/γ yield ratio is outlined. A value obtained for ^{203}Tl by this method is included. (D.C.W.)

3771 THE GALILEAN AND TRANSLATIONALLY INVARIANT OPERATOR ALGEBRA DESCRIBING NUCLEI. III. THE HARMONIC OSCILLATOR. Seyfferth, Siegfried (Univ., Goettingen, Ger.). Z. Phys., 207: 375-92(1967).

The Galilean and translationally invariant field operator formalism developed in the parts I and II is applied to the shell model with harmonic potential. In spite of the complicated structure of the commutation relations, some essential analogies to the non-invariant calculus can be verified. The unperturbed ground state can be described as a quasi-vacuum. Further, the one-particle density is diagonal in the energy representation. This fact admits the invariant use of the concepts of "occupied" and "unoccupied" states, in a somewhat modified, but well-defined sense. (auth)

3772 SPACE–TIME EVOLUTION OF ELASTIC SCATTERING. Jeukenne, J. P. (Univ., Liege). Bull. Soc. Roy. Sci. Liege, 36: 273-84(1967). (In French).

The behavior of a time-dependent wave packet associated with the elastic scattering of a neutron by a nucleus is analyzed, the interaction being represented by a real potential of finite depth and range. In the case of a narrow resonance, the scattered wave packet is shown to display characteristic properties of the time evolution of a metastable compound nucleus. (auth)

3773 INTERNAL CONVERSION COEFFICIENTS AT GAMMA-RAY THRESHOLD ENERGIES. O'Connell, R. F. (Goddard Space Flight Center, New York); Carroll, C. O. Nucl. Data, Sect. A 3: 287-325(Oct. 1967).

Internal conversion coefficients, for threshold values of the gamma-ray energy, are presented for the K-shell, L-subshells, and M-subshells for all values of Z in the range $6 \leq Z \leq 95$, and for the first five electric and magnetic multipoles. These numbers are based upon the exact analytical results previously obtained by the authors for the internal conversion coefficients for any shell and for any energy for a point nucleus with no screening. (auth)

3774 WORLD-WIDE NEWS OF COMPILATIONS IN NUCLEAR PHYSICS. Nucl. Data, Sect. A 3: 361-5(Oct. 1967).

Two abstracts of tables related to angular-correlation coefficients are presented. Attention is also called to a paper on gamma-ray angular distributions which appeared recently in Reviews of Modern Physics. (auth)

3775 SCATTERING OF POLARIZED ELECTRONS BY NUCLEI WITH MAGNETIC MOMENTS. Lin, Shin-r; Taylor, Mark F.; Gluckstern, Robert L. (Univ. of Massachusetts, Amherst). Phys. Rev., 163: 997-9(Nov. 20, 1967).

The cross section and asymmetry function S were calculated in the static limit for the scattering of polarized electrons from a point target with charge and magnetic moment, in the first and second Born approximations. The asymmetry, which vanishes in first order for both polarized and unpolarized incident electrons and for aligned and randomly oriented target spin, is found to be nonvanishing in second order for the scattering of polarized electrons from randomly oriented spin targets. The calculated

S contains contributions from both charge and magnetic scattering. Previous results established that S for Mott scattering has its maximum near 180° and that the position of this maximum approaches 180° as the incident electron energy increases. The possibility that these features can be used in conjunction with the results of the present calculation to obtain information about the magnetic structure of nuclei by measuring the deviation from the Mott scattering behavior of S at backward angles where magnetic scattering is important is discussed. A precision measurement of S appears to be necessary. (auth)

3776 THE ELECTROMAGNETIC RADII AND COULOMB ENERGY OF ^{3}He. Kiang, D.; Ng, S. H. (Dalhousie Univ., Halifax, Can.). Nucl. Phys., A104: 538-44(1967).

The accuracy and justification of a perturbation calculation of Coulomb energy and electromagnetic radii of ^{3}He are examined. It is found that the perturbation results differ from the exact ones by less than 2% for the Coulomb energy and by less than 6% for the electromagnetic radii. (auth)

3777 A MODIFICATION OF THE AUSTERN–BLAIR THEORY AND THE STUDY OF (α,α,γ) CORRELATION FUNCTIONS. Hahne, F. J. W. (Univ. of Cape Town. CSIR, Pretoria). Nucl. Phys., A104: 545-63(1967).

The Austern-Blair theory for single excitations, which relates the inelastic and elastic S-matrix elements in l-space for strongly absorbed particles, is slightly modified to include non-adiabatic effects. The characteristic features of some $(\alpha,\alpha'\gamma)$ correlation parameters are successfully described by this method. At the same time the extracted nuclear deformation parameters are in better agreement with those obtained in distorted wave Born approximation. (auth)

3778 ON THE FACTORIZATION OF THE WAVE FUNCTION AND THE GREEN FUNCTION IN THE REGION OF ISOLATED POLES OF THE S-FUNCTION. Unger, H.-J. (Moscow State Univ.). Nucl. Phys., A104: 564-76(1967).

The Breit-Wigner formula for isolated levels for scattering on diffuse edge potentials is deduced. The most effective choice of parameters necessary for the determination of energy eigenvalues is discussed. Also obtained is the factorization of the wave function and the Green function of the continuous spectrum in the region of isolated poles of the S-function. In the range of low energy, an approximation of the penetrability and the shift factor for potentials with a diffuse edge are deduced. (auth)

3779 STABILITY OF NUCLEI AGAINST PEAR-SHAPED DEFORMATIONS. Krappe, H. J. (Univ., Tuebingen, Ger. Hahn-Meitner-Inst. fuer Kernforschung, Berlin); Wahsweiler, H. G. Nucl. Phys., A104: 633-41(1967).

The eigenvalues and eigenfunctions for a pear-shaped oscillator well are determined. Determinant wave functions for ^{16}O, ^{20}Ne, and ^{24}Mg are constructed from these single-particle functions, and the expectation value of an A-particle Hamiltonian with simple two-body forces is calculated. Equilibrium quadrupole deformations are found at roughly the same values as expected from self-consistent Hartree-Bogoliubov calculations. Though no equilibrium octupole deformation could be definitely established, a remarkable softness against these deformations for 2s-1d shell nuclei is found. (auth)

3780 DEFORMED BINDING FIELDS. II. DEFORMED WAVE FUNCTIONS IN ^{6}Li ARISING FROM THE TENSOR FORCE. Freed, N. (Pennsylvania State Univ., University Park); Goldhammer, Paul. Contract AT(11-1)-1120. Nucl. Phys., A104: 683-91(1967). (COO–1120-57).

A Hill-Wheeler representation is used to provide variational wave functions in a calculation of the T = 0 levels of ^{6}Li. The model Hamiltonian contains a harmonic central force as well as a tensor interaction. It is found that the lowest levels with J = 1, 2, and 3 may be generated from a single intrinsic function with approximately the same stationary values of the variational parameters for each level and thus form a kind of collective band. The level scheme indicates that the vector effects of the tensor force have been taken into account. It appears that the α-particle core is soft towards deformation caused by the 1p nucleons. (auth)

3781 NUCLEAR MATRIX ELEMENTS OF FIRST-FORBIDDEN BETA TRANSITIONS IN THE NILSSON MODEL. Bogdan, D.; Lipnik, P. (International Atomic Energy Agency, Trieste, Italy). Nuovo Cim. (10), 51B: 375-403(Oct. 11, 1967).

The influence of the η and μ Nilsson parameters on the beta-decay of ^{186,189}Re and ^{170}Tm nuclei was studied. For the Re nuclei, good agreement between Nilsson-model predictions and experimental results was obtained by a reasonable variation of these parameters. In the case of ^{170}Tm, the high ft values can not be explained with such a variation of the model parameters. Some of these results were obtained by putting the nuclear parameters in a suitable form, using a new parametrization for the nuclear matrix elements in the framework of the Nilsson model. (auth)

3782 ANALYSIS OF STATISTICAL REACTION SPECTRA. Gadioli, E.; Zetta, L. (Univ., Milan. Istituto Nazionale di Fisica Nucleare, Milan). Nuovo Cim. (10), 51A: 1074-89 (Oct. 21, 1967).

The approximations usually made in order to simplify the analysis of the spectra of particles emitted in statistical reactions are tested. It is shown that these approximations, especially in the case of reactions on light target nuclei do not give a correct estimation of the parameters characterizing the level density of residual nuclei. New approximations are suggested which allow a very simple and much more accurate analysis of the experimental results. Both the integrated and the differential cross sections are discussed and the theoretical deductions are tested by analyzing spectra calculated with Hauser and Feshbach's theory. (auth)

3783 ON THE REARRANGEMENT ENERGY OF THE NUCLEAR MANY-BODY PROBLEM. Grypeos, M. E. (International Centre for Theoretical Physics, Trieste, Italy). Nuovo Cim. (10), 51B: 347-56(Oct. 11, 1967).

Mittelstaedt's definition of the rearrangement energy, which is related to many-body calculations for the separation energy of a particle by means of model wave functions, is extended in a straightforward manner to the case in which a trial many-body wave function is used. The "trial rearrangement energy" so defined is studied in the case of the separation of a particle s from a system of A + 1 particles in which the A particles (nucleons) are not identical to the s. In this treatment a Jastrow-like trial wave function is used. Some general properties of this this trial rearrangement energy are derived, and the first term of its cluster expansion is given in the case in which the A nucleons form an infinite nuclear matter of density ρ. Numerical estimates of this first-order term are performed for a case of physical interest. (auth)

3784 QUASI-FREE PROTON–PROTON SCATTERING ON DEFORMED NUCLEI. Kudo, Yoshiteru; Suekane, Shota (Osaka City Univ.). Progr. Theor. Phys. (Kyoto), 38: 520-2(1967).

It is shown that information on deformed nuclear states can be obtained using the (p,2p) reaction. Angular correlation distributions are calculated for the reaction ^{27}Al(p,2p)^{26}Mg. It is concluded that the angular correlation distribution is sensitive to the nuclear deformed and that the (p,2p) reaction can be used to obtain information on deformed single-proton states. (D.C.W.)

3785 SPECTROSCOPIC FACTORS IN THE DISTORTED-WAVE THEORY OF THREE-NUCLEON STRIPPING PROCESSES. Abul-Magd, A. Y.; El-Nadi, M.; Sharaf, M. A. (Atomic Energy Establishment, Cairo. Cairo Univ.). Progr. Theor. Phys. (Kyoto), 38: 366-81(Aug. 1967).

A distorted-wave theory is developed for three-nucleon stripping reactions, which takes account of the antisymmetrization of the nuclear wave functions and the exchange character and finite range of the effective forces that are responsible for the reaction. The evaluation of the transition amplitude involves two steps; the construction of the spectroscopic factors which characterize the involved nuclear states and the calculation of the stripping integrals which depend on the dynamics of the reaction. Expressions for the spectroscopic factors are given for the case in which the nuclear wave functions are expressed by the shell model with three nucleons captured in similar or different shells. The stripping integrals are put in a simple form, similar to that used in the zero-range of (d,p) reactions with the help of the local energy approximation and the generalized Talmi transformation. (auth)

3786 NUCLEAR MATTER CALCULATIONS WITH SOFT-CORE POTENTIALS IN MOMENTUM SPACE. II. Harada, Minoru (Otaru Univ. of Commerce, Japan). Progr. Theor. Phys. (Kyoto), 38: 353-65(Aug. 1967).

The binding energy of nuclear matter was determined with a most up-to-date nucleon–nucleon potential by solving the reaction matrix equation of the Brueckner theory self-consistently in momentum space. The potential has Gaussian soft cores, joins the OPEP at large distances and reproduces two-nucleon scattering data quite satisfactorily. Off-energy-shell propagation was treated accurately and was found to reduce the binding energy no more than 0.7 MeV per particle in contrast with the result of Coon and Dabrowski and with Bethe et al.'s arguments. It is found that the calculated binding energy ranges from 10.3 MeV at the equilibrium spacing of 1.15 fm to 13.1 MeV at 1.02 fm as the central-tensor force ratio is varied. This shows that the Brueckner theory, with its first-order calculation, is able to reproduce more than 80% of the semiempirical value for the

binding energy of nuclear matter with realistic nucleon-nucleon potentials. (auth)

3787 TABLES OF COEFFICIENTS FOR ANGULAR DISTRIBUTION OF GAMMA RAYS FROM ALIGNED NUCLEI. Yamazaki, T. (Univ. of California, Berkeley). Nucl. Data, Sect. A, 3: No. 1, 1-24(Aug. 1967).

A simplified formulation of angular-distribution functions is presented together with tables of coefficients for the angular distributions of gamma rays from aligned nuclei. (D.C.W.)

3788 TABLES OF COEFFICIENTS FOR ANGULAR CORRELATIONS OF RADIATIVE TRANSITIONS FROM ALIGNED NUCLEI. Watson, D. D.; Harris, Gale I. (Aerospace Research Labs., Wright-Patterson AFB, Ohio). Nucl. Data, Sect. A, 3: No. 1, 25-122(Aug. 1967).

Basic formulas and tabulations of numerical coefficients are provided for the analysis of data on angular correlations of successive radiative transitions from aligned nuclei. The formulas are extracted from a previously published development of the angular-correlation formalism. This development is based upon a factored version of the equations which is used to extend the application from the usual two-step cascade to general multiple-step cascades. The resulting flexibility and greater efficiency of the formalism are utilized to provide an extensive tabulation of coefficients for a variety of specific applications. Coefficients are provided for analysis in terms of either the population parameters or the statistical tensors of the aligned state. The coefficients can be used for the analysis of angular distributions, linear polarizations, and triple correlations involving one or more intermediate unobserved radiations. In contrast to previous tabulations of coefficients for angular-correlation analysis, the range of the present tables has been extended to include multipolarities through octupole. The overall length of the tables, however, remains about the same as previous tables because of the greater efficiency of the factored formalism. The range of spins covered by the tables are $J \leq 11/2$ for the initial aligned state and $J \leq 21/2$ for the final state of the cascade. (auth)

3789 IDENTIFICATION OF THE MECHANISM OF THREE-PARTICLE DIRECT REACTIONS. Dubovoi, E. I.; Shapiro, I. S. Zh. Eksp. Teor. Fiz., 53: 1395-9(Oct. 1967). (In Russian).

It is shown that the amplitudes for direct nuclear reactions involving the formation of three particles and corresponding to triangular knock-out diagrams with rearrangement of the nuclei at the vertexes can be expressed in terms of a universal function of two dimensionless variables for arbitrary masses of the particles. The behavior of the differential cross section near the singularities is calculated, and maps of the level lines of the respective surfaces are presented. Comparison of the data obtained with the experimental data permits one to establish the mechanism of the reaction. (auth)

3790 SCREENING CORRECTION TO β DECAY. Yamada, Masami (Waseda Univ., Tokyo). Waseda Daigaku Rikogaku Kenkyusho Hokoku, No. 36, 67-75(Sept. 1966). (In Japanese).

The screening correction to nuclear β-decay was calculated with the aid of an electronic computer. In conformity with the Matumoto–Yamada theory of β decay, the correction factor for each partial wave function of electron or positron is computed separately. The wave functions for which calculations are made are those with the quantum number $\kappa = \pm 1$, and ± 2. The screening correction to the allowed and first-forbidden β decays can be easily calculated from the correction factors of these wave functions. The screened potential used in the computation is an approximate Thomas–Fermi potential represented by a rational function. The effect of the small change in the screened potential is also examined. The results given in both tabular and graphical forms are in good agreement with those obtained by the Rose method, but not with those of Longmire and Brown and of Reitz. (NSA of Japan)

3791 APPLICATION OF THE REACTION-MATRIX THEORY. II. SIMPLE BRUECKNER–HARTREE–FOCK DESCRIPTIONS OF THE GROUND STATES OF LIGHT NUCLEI. Wong, Chun Wa (Princeton Univ., N. J. Oxford Univ.). Nucl. Phys., A104: 417-58(1967).

The derivation of the nuclear single-particle (s.p.) shell model from realistic free-space nucleon-nucleon potentials is studied both theoretically and quantitatively. A Brueckner-Hartree-Fock (BHF) s.p. model is constructed which contains a reaction- matrix HF s.p. potential and a potential coming from other many-body correlations. The s.p. Hamiltonian is defined diagrammatically. The nature of the resulting s.p. states and the relation between the resulting s.p. energies and the corresponding energies in nuclear matter are elucidated. Particular attention is paid to the important third-order hole-hole re-arrangement potential, which is calculated explicitly with finite geometry. This BHF model is then used to study quantitatively the ground-state properties of the light nuclei ^{40}Ca, ^{16}O, and ^{4}He using a number of hard-core nucleon-nucleon potentials, some with non-central forces. It is found that the calculation underbinds these light nuclei by 2 to 4 MeV per particle for realistic potentials but does give rough agreement in the nuclear radii except in ^{4}He. The calculation does not give the correct s.p. removal energies, with or without the inclusion of the second- and third-order re-arrangement potentials. It also gives only half of the empirical spin-orbit splitting. It is further estimated that a realistic nucleon-nucleon potential giving the correct binding energy in nuclear matter will correctly bind these light nuclei if the contribution of long-range ground-state correlations is included. The nuclear size will also be roughly correct. Comparison between the calculation and a number of other calculations in the literature is made in some detail. (auth)

3792 ANALYSIS OF UNIQUE BETA TRANSITIONS. Eman, B. (Univ. of Zagreb); Krmpotic, F.; Tadic, D.; Nielsen, A. Nucl. Phys., A104: 386-400(1967).

Measurements of unique forbidden β transitions were analyzed. It was found that experimental shape factors can be reproduced only with the induced pseudoscalar form factor $d < 0$, and/or with the induced G-non-conserving tensor form factor $b > 0$. In the former case they contradict published results for $0^- \rightarrow 0^+$ transitions, whereas in the latter they are in disagreement with other known analyses of μ-meson capture, allowed and forbidden transitions. The conclusion appears to be independent of limited variations of nuclear matrix element ratios. A complete theoretical expression for the shape factor and details of the analysis are presented. (auth)

3793 UNIFIED PERSPECTIVE OF VIBRATIONAL AND ROTATIONAL MODELS OF THE NUCLEUS. Sakai, Mitsuo (Tokyo Univ.). Nucl. Phys., A104: 301-26(1967).

Quasi-beta and quasi-gamma bands with the spin sequence 0^+, 2^+, 4^+, ... and 2^+, 3^+, 4^+, ... are proposed based on the large amount of the experimental data up to date. They appear in the excited level system of doubly even nuclei in the whole nuclear regions. The heads of the bands in the vibrational region are the 0^+ and 2^+ states of the two-phonon triplet. They tend smoothly to the beta and gamma bands in the rotational region through the transition region. The relative location of the head states of the quasi bands with respect to the first excited 2^+ state was found to be a good measure for the deformation of the nucleus. It is a much more sensitive quantity than the energy ratio of the second 4^+ state to the first 2^+ state. This view may be called as longitudinal coordination of the excited states by choosing an inherently related special member of the higher phonon states while the usual phonon model can be called as lateral coordination of the excited states. In the latter model no correlation is predicted among the individual members of excited states with different phonon number. The longitudinal coordination seems to present a clue for explaining the nuclear excitation mechanism in a more comprehensive way. In other words, it provides a unified perspective of the vibrational and rotational models. The relation between the longitudinal and lateral coordinations of the excited states is discussed briefly in terms of the gamma-unstable model. (auth)

3794 NUCLEAR MATTER CALCULATIONS USING SEPARABLE POTENTIALS. Bhakar, B. S.; McCarthy, R. J. (Rice Univ., Houston, Tex.). Contract AT(40-1)-1316. Nucl. Phys., A104: 283-8(1967). (ORO-1316-37).

The binding energy per particle and saturation density of nuclear matter are calculated using reaction matrix theory for a number of separable potentials in current use. None of the potentials tested yield satisfactory results but a separable potential which combines the desirable features of the Tabakin and Puff potentials should be able to fit nuclear matter and nucleon-nucleon scattering data. However, it appears doubtful that a separable potential can be found which can fit nuclear matter and nucleon-nucleon scattering data and still be suitable for nuclear Hartree-Fock calculation. (auth)

3795 PROCEEDINGS OF THE LIPERI SUMMER SCHOOL IN THEORETICAL PHYSICS, AUGUST 1–6, 1966. B. NUCLEAR PHYSICS. Helsinki, University of Helsinki, 1967. 166p. (CONF-660834-(Pt.B)). DTIE.

Separate abstracts were prepared for the six lectures included. (D.C.W.)

For abstracts of individual papers see: 3796–3801.

3796 COLLECTIVE EFFECTS IN SPHERICAL NUCLEI. Sorensen, Raymond A. (Carnegie Inst. of Tech., Pittsburgh). pp 3-24 of Proceedings of the Liperi Summer School in Theoretical Physics, August 1–6, 1966. B. Nuclear Physics. Helsinki, University of Helsinki, 1967.

See CONF-660834-(Pt.B).

A qualitative description is presented of various collective motions in which a large number of nucleons are coherently involved. It is shown that many kinds of collective states, including analog states, can be treated with essentially the same formalism (random phase approximation), but that the range of validity of the formalism is very much in doubt. (D.C.W.)

3797 PARITY DEFORMATION AND PAIRING WITHIN A SOLVABLE MODEL. Schuette, Dieter (Univ., Bonn). pp 25-55 of Proceedings of the Liperi Summer School in Theoretical Physics, August 1-6, 1966. B. Nuclear Physics. Helsinki, University of Helsinki, 1967.

See CONF-660834-(Pt.B).

A model incorporating deformation of the single-particle orbitals with respect to parity is formulated, and the validity of different approximation techniques is established. The Hartree-Fock approximation, projection methods of the Hartree-Fock approximation, perturbation theory, and the random phase approximation are applied to the model; the results are compared to exact solutions. The effects of including pairing matrix elements are also studied. (D.C.W.)

3798 PAIRING MODEL WITH SPECIAL ATTENTION TO DEFORMED MODEL. Wahlborn, S. (Research Inst. for Physics, Stockholm). pp 56-69 of Proceedings of the Liperi Summer School in Theoretical Physics, August 1-6, 1966. B. Nuclear Physics. Helsinki, University of Helsinki, 1967.

See CONF-660834-(Pt.B).

A general model for pairing in a system of nucleons is formulated with emphasis on deformed nuclei. It is shown that the formalism has good phenomenological justification for the case of particle states in most heavy nuclei. (D.C.W.)

3799 ALPHA DECAY THEORY. Sandulescu, A. (Research Inst. for Theoretical Physics, Helsinki. Inst. for Atomic Physics, Bucharest). pp 70-103 of Proceedings of the Liperi Summer School in Theoretical Physics, August 1-6, 1966. B. Nuclear Physics. Helsinki, University of Helsinki, 1967.

See CONF-660834-(Pt.B).

A brief review of recent improvements in the theoretical description of alpha decay is presented. The alpha-nucleus potential is analyzed, and the relation between the Coulomb and nuclear potentials and the corresponding potentials for nucleons are studied. The actual microscopic theory of alpha decay which can connect the levels of bound nucleons with alpha decay rates is then described on the basis of a simple model of two spinless particles in a harmonic oscillator potential. Theoretical predictions are compared with experimental data for both deformed and spherical nuclei. (D.C.W.)

3800 RECENT DEVELOPMENT IN DIRECT REACTION THEORY. Kuemmel, H. (Max-Planck-Institut fuer Chemie, Mainz). pp 104-29 of Proceedings of the Liperi Summer School in Theoretical Physics, August 1-6, 1966. B. Nuclear Physics. Helsinki, University of Helsinki, 1967.

See CONF-660834-(Pt.B).

The theory of direct reactions is discussed with emphasis on the problems in the theory and their solutions. The (d,p) reaction is used as an example, and the validity of the distorted-wave Born approximation is considered in some detail. (D.C.W.)

3801 OPTICAL POTENTIALS FOR COMPOSITE PARTICLES. Bencze, Gy. (Research Inst. for Theoretical Physics, Helsinki. Central Research Inst. for Physics, Budapest). pp 130-62 of Proceedings of the Liperi Summer School in Theoretical Physics, August 1-6, 1966. B. Nuclear Physics. Helsinki, University of Helsinki, 1967.

See CONF-660834-(Pt.B).

The formulation of optical-model potentials for composite particles in terms of the potentials for the constituent nucleons is discussed. The properties of the first-order potentials for light particles such as deuterons, tritons, ^{3}He ions, and alpha particles are considered as examples. (D.C.W.)

3802 RADIATIVE PION ABSORPTION AND THE STRUCTURE OF LIGHT NUCLEI. Anderson, David Kyle. Charlottesville, Va., Univ. of Virginia, 1966. 99p.

Thesis.

A theoretical investigation of radiative pion absorption by certain light nuclei is carried out. The impulse approximation is used to derive a transition operator for this reaction from the inverse process of pion photoproduction. It is shown that spin and isospin dependent collective vibrations play a dominant role in the process and it is concluded that radiative absorption can be used to study such excitations. The probability of radiative absorption is estimated and is in agreement with experiment. (Disser. Abstr.)

3803 STUDY OF COLLECTIVE STATES OF NUCLEI BY INELASTIC ELECTRON SCATTERING. Wu, Chi-shiang. Cleveland, Western Reserve Univ., 1966. 105p.

Thesis.

The collective excitation of nuclei by high energy electrons is studied using a microscopic model of the collective vibrational state of nuclei based on shell model particles interacting via residual forces, pairing plus quadrupole and octupole forces. Although the collective model, called a macroscopic model, was shown to give a fairly good account of the inelastic electron scattering in a low momentum transfer region so far experimentally tested, it is expected that the microscopic structure of nuclei must be reflected in the inelastic electron scattering. Collective excitations from ground states to one phonon vibrational states are studied. In the first place, a complete interaction Hamiltonian, including nucleon convection and spin current, is used in a first Born approximation study of the scattering, which shows that the Coulomb interaction is dominant in the case of collective excitation even though it is not so in the case of a single-particle excitation. In order to reifne the result of the first Born approximation, the distorted wave effect is taken into account by including the second Born terms in the scattering amplitude which correspond to two-phonon exchange processes. The second Born term is evaluated by a numerical integration over a complex momentum plane. The result of such calculation for a quadrupole excitation of ^{58}Ni shows that this method is able to account for most of the distorted wave effect except in a narrow momentum transfer region where the first and second Born terms cancel to a very small value and accordingly the higher order terms become important. A systematic study of quadrupole excitations are carried out in the first Born approximation for nuclei in 50-82 shell. The dependence of the inelastic scattering cross section on the single-particle wave function as well as on the admixing of single particle states caused by the residual forces are discussed. Some octupole excitations are also calculated in first Born approximation, and they are shown to be in fair agreement with experimental results in a low momentum transfer region. As a general conclusion, it is found that the scattering cross section is rather insensitive to the detailed structure of the nucleus in the low momentum transfer region, and that the electron scattering experiment must by extended to a sufficiently high momentum transfer region in order to see the effect of the detailed structure of the nucleus. (Disser. Abstr.)

3804 INTRODUKTION TILL KAERNFYSIKEN. (Introduction to Nuclear Physics). Johansson, S. Introduktion Till Vetenskaperna. (Introduction to Natural Sciences). Stockholm, Natur och Kultur, 1967. 256p. Sw. Crs 25.00 paperback; Sw. Crs 30.00 bound.

An introductory textbook in nuclear physics is presented. The following subjects are briefly described: nuclear structure; interactions between radiation and matter; radiation detection; alpha and beta decay; principles of accelerators; nuclear and thermonuclear reactions; neutron physics; nuclear reactors; nuclear forces; elementary particles; cosmic radiation and astrophysics; and applications within agriculture, chemistry, geology, and life sciences. (SWEDEN)

REACTOR TECHNOLOGY

Central Power Reactors

Refer also to abstracts 2017, 2172, 2230, 2265, 2279, 2285, 2291, 2297, 2573, 2620, 2662, and 3599.

3805 (ACNP–67530) SECOND MONTHLY OPERATIONAL REPORT ON THE LA CROSSE BOILING WATER REACTOR FOR THE MONTH OF AUGUST 1967. (Allis-Chalmers Mfg. Co., Bethesda, Md. Atomic Energy Div.). Contract AT(11-1)-850. 57p. Dep. CFSTI.

The low power program continued during August until its successful completion on August 24, 1967. Tests 105 and 107 were conducted concurrently and without difficulties during the first half of the month. Five separate H_3Bo_3 concentrations were utilized. From the results of Test 105 it is concluded that the core (cold, unrodded) k_{eff} is 1.20 ± 0.005. Additional information for use in determination of the shutdown margin was obtained (Test 104). The Sb rod, activated at Babcock and Wilcox's test reactor, was received on August 9, 1967 and was placed in the reactor on August 21. Due to the low count rates obtained on one of the source range channels, provisions have been made to place a second Sb-Be source in the reactor prior to power escalation. Gas leakage from some of the control rod drive accumulators was the only equipment malfunction of any significance which occurred during the month. (auth)

3806 (ACNP–67532) LA CROSSE BOILING WATER REACTOR. Third Monthly Operational Report, September 1967. (Allis-Chalmers Mfg. Co., Bethesda, Md. Atomic Energy Div.). Contract AT(11-1)-850. 15p. Dep. CFSTI.

Commencing on September 5, 1967, after the completion of the low power startup program, construction of the items required for power operation was resumed. The only construction items completed during the month were the alternate core spray system (installed but not insulated) and the control rod nozzle support structure. Work was started on the baffle plate skirt on the core spray bundle, on installation of the shutdown condenser vent valves, and on all the instrumentation required to monitor the containment building following a maximum credible accident (MCA). A list of maintenance items was compiled for completion during the shutdown. The containment building insulation was repaired where needed. The 10 in-core detectors and cables were installed and tested. The 7 new carbon steel cables operated satisfactorily through 40 cycles, but the 3 titanium cables continued to jam after a few cycles and were returned to the vendor for replacement with carbon steel cables. The only testing conducted during the month was a flow test performed on the forced circulation pumps. A weight loss test on the fuel elements and shroud can plugs for different forced circulation flow rates was also performed. (auth)

3807 (AE-299) THE MEASUREMENT OF EPITHERMAL-TO-THERMAL ^{238}U NEUTRON CAPTURE RATE (ρ_{28}) IN AGESTA POWER REACTOR FUEL. Bernander, G. (Aktiebolaget Atomenergi, Stockholm (Sweden)). Sept. 1967. 42p. Dep.

The epithermal-to-thermal neutron capture rate ratio $\rho_{28}/^{238}U$ in Agesta fuel was determined by the chemical separation method. The method involves the isolation of ^{239}Np from U and fission products by reversed phase partition chromatography. The separation of the epithermal ^{235}U activation from the total was achieved by means of the "1/v subtraction technique" using copper foils as the 1/v monitor. The complementary thermal column irradiations required were performed in the research reactors TRIGA (Helsinki) and RI (Stockholm). From the measured ρ_{28} values the resonance escape probability (p) and the initial conversion ratio (ICR) may be calculated using cross-section data and other lattice parameters. Comparisons with theoretical values of p and ICR as calculated with the BURNUP lattice parameters code are favourable. (auth) (SWED)

3808 (AECL–2928) TECHNOLOGICAL PROGRESS IN CANADIAN NUCLEAR FUELS. Hart, R. G. (Atomic Energy of Canada Ltd., Pinawa (Manitoba). Whiteshell Nuclear Research Establishment). Aug. 1967. 17p. (CONF-670639–1). Dep. CFSTI. CAN $0.50.

From 12th Nuclear Congress on Technological Factors Determining the Development and Consequent Expansion of the Use of Power Reactors, Rome, Italy.

A review of Canadian nuclear fuel development emphasizing the versatility of Zr alloy clad, UO_2 fuel arranged in short, multi-rod bundles is presented. Designs suitable for use in pressurized water, boiling water and organic liquid cooled systems are described. The developments leading to fuelling costs of 0.68 mills/kWh in the first Pickering electricity generating stations are discussed. The current status of Canadian development work on UC and U_3Si fuels is also reviewed. (auth)

3809 (AECL–2941) MULTI-UNIT ASPECTS OF THE PICKERING GENERATING STATION. Morison, W. G. (Atomic Energy of Canada Ltd., Sheridan Park (Ontario)). Sept. 1967. 17p. (CONF-670917–9). Dep. CFSTI. CAN $0.50.

From Symposium on Heavy Water Power Reactors, Vienna, Austria.

The station has been planned and laid out on an eight unit station, four units of which have now been authorized for construction. Each of these four units consists of a single heavy water moderated and cooled CANDU type reactor and auxiliaries coupled to a single tandem compound turbine generator with a net output of approximately 500 MW(e). The units are identical and are scheduled to come into operation at intervals of one year from 1970 to 1973. The station has been planned with central facilities for: administration maintenance laboratories, stores, change rooms, decontamination and waste management services. A common control center, cooling water intake and discharge system and spent fuel storage bay for four units have been arranged. A feature of the multiunit station is a common containment system. (auth)

3810 (AECL–2942) CANDU-BLW-250. Pon, G. A. (Atomic Energy of Canada Ltd., Sheridan Park(Ontario)). Sept. 1967. 20p. (CONF-670917–6). Dep. CFSTI. CAN $0.50.

From Symposium on Heavy Water Power Reactors, Vienna, Austria.

The plant "La Centrale nucléaire de Gentilly" is located between Montreal and Quebec City on the south shore of the St. Lawrence River. Start-up is scheduled for 1971. A CANDU-BLW reactor is the nuclear steam generator. This reactor utilizes a heavy water moderator, natural uranium oxide fuel, and a boiling light water coolant. To be economic, this type of plant must have a minimum light water inventory in the reactor core. A minimum inventory is obtained by reducing the cross-sectional area for coolant flow to a minimum, and by operating at a low-coolant density. In CANDU-BLW-250, this is accomplished by operating a closed spaced fuel rod bundle at high steam quality. These features and others in the BLW concept lead to a number of areas of concern and they are summarized: heat transfer; hydrodynamic stability; control; and safety. (auth)

3811 (AECL–2946) COSTS AND ECONOMICS OF HEAVY WATER MODERATED NUCLEAR PLANTS. Haywood, L. R.; Aikin, A. M. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). Sept. 1967. 13p. (CONF-670917–5). Dep. CFSTI. CAN $0.50.

From Symposium on Heavy Water Power Reactors, Vienna, Austria.

The development of heavy water moderated power reactors in Canada has included studies of three coolant systems: heavy water, light water, and organic. Economic comparisons do not show large advantages of one system over the other, but each offers its own technical and operational advantage. As the heavy water cooled concept is the most advanced technically, with plants in operation, this system is used to show details of capital, fuel and operating costs. That such a system is economically competitive in the world market was shown recently in the bids for a reactor in Finland. The economic advantages and disadvantages of the alternate cooling systems are discussed. Fuel costs for the CANDU-PHW reactors are now less than 0.7 mills/kWh and are continuing to decrease. If credit is taken for the Pu produced, 1970 costs will be less than 0.5 mills/kWh. Further developments in fuel should be used to lower the capital costs. The history of heavy water costs is reviewed. Besides the expected lowering of capital costs by increasing unit sizes, building several plants of one design and combining many plants at one site, technical developments are also available that will give significant reductions in capital costs. Recent information confirms that UO_2 fuels can be run at significantly higher power ratings than in Douglas Point or Pickering reactors, thus the power output from similar sized cores could be raised by fifty percent. The use of U_3Si fuel and Pu recycle promise increased power densities in the natural U BLW reactor. Lower fuel costs will also allow higher operating temperature, and thus higher efficiency. The organic coolant system would have a low capital cost because of the low pressure system and the high thermal efficiency. The value of these developments, which total between $50/kWe and $100/kWe for a 500 MWe

station is given along with a schedule of expected capital and total unit energy cost reductions. 500 MWe CANDU nuclear stations committed for detailed design in 1972 will have all-inclusive capital costs in the range of $170 – $190 per kWe. (auth)

3812 (AECL-2947) OUTLOOK FOR HEAVY WATER REACTORS. Lewis, W. B. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). Sept. 1967. 15p. (CONF-670917-8). Dep. CFSTI. CAN $0.50.

From Symposium on Heavy Water Power Reactors, Vienna, Austria.

Details are given of several fuel cycle changes showing the inventories of fuel and heavy water involved in meeting market changes and the expectation of net fuel cycle costs being held in the range 0.3 to 0.6 mill/kWh in terms of today's dollar values despite a rise in the cost of U. The analysis shows possible interaction with other types of reactor including breeders. Reasons are given for welcoming any possible future competition or partnership from these types in meeting the growing world demand for harnessed energy. (auth)

3813 (AI-CE-54) HEAVY WATER ORGANIC COOLED REACTOR. Quarterly Technical Progress Report, April–June 1966. (Atomics International, Canoga Park, Calif. Combustion Engineering, Inc., Windsor, Conn.). Oct. 1, 1967. Contract AT(38-1)-430. 214p. Dep. CFSTI.

REACTOR SAFETY—accident analysis for HWOCR, maximum credible
REACTOR CONTROL ELEMENTS—reliability evaluation of HWOCR shutdown
HEAVY WATER ORGANIC-COOLED REACTOR—shutdown control rods for, reliability evaluation of; calandria pressure release analysis; fuel element cladding materials evaluation for; kinetics analysis of, space-time; pumps for, effects on economics of operating conditions of; cooling system for, evaluation of shutdown; containment systems for, analysis of various hemispherical; neutron buckling calculations in, effects of hydrogen scattering kernel on; coolants for, differential scanning calorimeter measurements of physical properties of; coolants for, chlorine analysis of terphenyl
REACTOR FUEL ELEMENTS—end plates for, effects on HWOCR performance of; radiation effects on uranium carbide SAP-clad
REACTORS, PROCESS HEAT—fuel elements for, design studies on; fuel cost calculations for; cooling systems for, design studies on; turbine plant studies for
REACTORS, POWER—fuel elements for dual-purpose, design studies on; fuel cost calculations for dual-purpose; cooling systems for dual-purpose, design studies on; turbine plant studies for
NEUTRONS—flux calculations for HWOCR, comparison of eigenvalues for; buckling calculations in HWOCR, effects of hydrogen scattering kernel on
SAP (SINTERED ALUMINUM POWDERS)—tensile properties of, testing of; stress measurements on
JOINTS—leakage testing of TS-10-Z rolled; testing and evaluation of SAP-steel transition; tensile testing of SAP-stainless steel rolled
URANIUM CARBIDES—synthesis experiments under reactor conditions on, results of; fuel module life tests on
TURBINES—cycle study for HWOCR
REACTIVITY—calculations for HWOCR, effects of hydrogen scattering kernel on
NEUTRONS, EPITHERMAL—resonance escape probabilities for, comparison of analyses of
TUBES—development of pressure
DIFFUSION—barrier studies for reactor joint interfaces
WELDS—tensile testing of magnetic force, results of
CALORIMETERS—use for measurement of melting behavior of organic coolants (M.L.S.)

3814 (BNWL-SA-1334) A METHOD FOR CALCULATION OF GROUP-AVERAGED RESONANCE PARAMETERS. Nail, James H.; Sheff, James R.; Robinson, Alan H. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Nov. 2, 1967. Contract AT(45-1)-1830. 31p. (CONF-671102-34). Dep. CFSTI.

From 15th Conference on Remote Systems Technology and Atom Fair, Chicago, Ill.

A method of averaging resonance parameters of multiple energy group calculations of resonance cross sections is presented. The method generates average resonance parameters which require only only a few pieces of storage information compared to the large amount of storage information required for most isotopes. The narrow resonance-infinite absorber assumption is used for the approximation. (D.C.C.)

3815 (BNWL-SA-1443) MODEL DEVELOPMENT CONSIDERATIONS IN THE SIMULATION OF FAST NUCLEAR POWER PLANTS. Gerhardstein, L. H. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Oct. 12, 1967. Contract AT(45-1)-1830. 23p. (CONF-671032-1). Dep. CFSTI.

From Northwest Simulation Council Meeting, Richland, Wash.

Simulation of the Fast Flux Test Facility main heat removal system and controls is being accomplished on the BNW hybrid computer, Beckman EASE 2133 analog, and DEC PDP-7 digital computer. Areas of simulation include: hazards analysis; general system stability; control requirements; and operator training. (D.C.C.)

3816 (CEA-Bib-79) RUPTURE DE TUBES ET CAISSONS DE REACTEURS NUCLEAIRES. (Failures in Pipes and Pressure Vessels Correlated to Nuclear Power Plant Service). Le Levier, Marie-Genevieve (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Sept. 1967. 32p. (In French). Dep.

The papers published on the failures in pipes and pressure vessels correlated to nuclear power plant service are described. These references were selected from Bibliographic Indexes published from 1963 to July 1966 inclusive. The abstracts of the papers are included. 108 references. (auth)

3817 (COO-651-49) ELK RIVER REACTOR SYSTEM MONITORING DATA, JULY 1, 1966–JUNE 30, 1967. (Rural Cooperative Power Association, Elk River, Minn.). Contract AT(11-1)-651. 76p. Dep. CFSTI.

A general summary of all monitoring and radiochemical activities which occurred during the report period is presented. A major problem encountered was the occurrence of major fuel defects in the Elk River Reactor. This resulted in (1) greater stack releases since the use of the off-gas system was required, (2) compounded problems associated with activity leakage from the primary system to the secondary system through leaking heat exchanger tubes, (3) increased direct radiation levels in most areas of the containment vessel because of increased activity in the primary coolant, (4) periods of increased containment vessel air activity because of leakage in the off-gas system piping and occasional spurious building isolation damper trips, and (5) increased activity in the primary coolant. (H.D.R.)

3818 (DER-7(Rev.)) A PRELIMINARY ASSESSMENT ON THE USE OF HEAVY WATER THORIUM REACTORS IN THE BRAZILIAN NUCLEAR PROGRAM. Brito, Sergio de Salvo; Lepecki, Witold P. S. (Minas Gerais Univ., Belo Horizonte (Brazil). Divisao de Engenharia de Reatores). July 1967. 34p. (CONF-670917-4).

From Symposium on Heavy Water Power Reactors, Vienna, Austria.

Results of a study on the feasibility of a Th reactors program in Brazil are presented. A reference conceptual design of heavy water-cooled and -moderated thorium converter is discussed. Preliminary feed materials studies are outlined. (M.L.S.)

3819 (DLCS-5000267) QUARTERLY OPERATING REPORT. Second Quarter, 1967. (Duquesne Light Co., Shippingport, Pa. Power Stations Dept.). Contract AT(11-1)-292. 22p. Dep. CFSTI.

The Heat Dissipation System remained shut down during the second quarter. The Station operated with three reactor coolant loops (1A, 1C and 1D) in service. The 1B reactor coolant loop remained isolated for steam generator tube testing and repairs. Three scheduled shutdowns were performed during the quarterly period. A new reactor control rod programming sequence was approved for performance and instituted May 15. Routine chemistry analysis of the boiler water for fluorine-18 performed May 18, indicated a primary to secondary tube leak in the 1C coolant loop steam generator. (auth)

3820 (EUR-3489i) CENTRALE ELETTRONUCLEARE DEL GARIGLIANO. Relazione Annuale, 1966. (Garigliano Nuclear Power Plant. Annual Report, 1966). (Ente Nazionale per l'Energia Elettrica, Rome (Italy)). May 2, 1967. 102p. (In Italian). Dep.

The Garigliano Station operating history for the period from May 1, 1966 to February 28, 1967 is given. The plant operated with an availability factor of about 89% and generated a total of approximately 1000 million kWhrs. The average fuel burnup since the plant was placed on line reached 7730 MWd/t of uranium, corresponding to a consumption of about 235 kg of U-235 and a production of about 184 kg of plutonium. A number of tests were performed to assess the stability of the reactor under higher power density and void content conditions. These tests also demonstrated the good stability of the reactor in very severe operating conditions. With regard to core performance, various control rod

patterns and withdrawal sequences were considered in order to determine those giving highest uniformity in fuel consumption. In these studies, the computer proved to be an essential tool. It allowed a considerable amount of data to be collected and processed very quickly, thus providing extremely useful information on power distribution and, in general, on the thermohydraulic parameters which characterize core performance. The core pressure drop gradually increased, but was always well within the operation safety limits. In this reporting period, the Δp rose from 1.61 to 5.66 psi at a daily rate of 0.016 psi. The suspended material in the primary circuit water—with iron prevailing over copper and nickel—remained at relatively low values. Instead, an increased copper content, contributed more or less in the same measure by the high-temperature and low-temperature heaters, was found in the dissolved corrosion products. The amount of corrosion products in solution was also rather low. The plant radiation levels in the reporting period did not differ substantially. As to personnel health physics, the use of whole body counters allowed immediate checks and a constant control of the efficiency of the equipment and procedures adopted at the site. (auth)

3821 (EUR-3557e) TEMPERATURE AND THERMAL STRESS DISTRIBUTION IN SMOOTH AND FINNED CANNINGS DUE TO AXIAL FLUX VARIATIONS. Reynen, J. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 1967. 44p. Dep.

Temperature and thermal stress distributions due to thermal neutron flux peaking near the end plugs of fuel rods are determined for both smooth and finned cannings. The theory has been programmed on a digital computer. The code, named ATEAS, handles empirical flux distributions defined at a number of discrete points by assuming a linear flux distribution between adjacent points. (auth)

3822 (EUR-3609e) SENA SAFETY EVALUATION: FACTORS INVOLVED IN THE EVALUATION OF THE MAXIMUM CREDIBLE BORON RELEASE FROM THE CORE SURFACES OF A PWR WITH CHEMICAL SHIM. Petrangeli, G. (Comitato Nazionale per l'Energia Nuclear, Rome (Italy)). 1967. 12p. Dep.

A basis for the evaluation of an upper limit of reactivity input for the commonly named "boron-hideout accident" is described. This accident would be caused by the sudden removal from core surfaces of previously deposited B. The following items are briefly treated: phenomena leading to B deposition on core surfaces; evaluation of the amount of crud deposited on core surfaces; evaluation of the amount of B absorbed by crud; B deposition due to the presence of alkali metaborates; B depositions due to boric aicd concentration on heat transfer surfaces; percentage of deposited crud which can be released during thermal transients; evaluation of reactivity release in a "boron-hideout accident". Experimental data on the phenomena possibly leading to B deposition and release from core surfaces have been collected, critically evaluated and presented. A method is also described for the evaluation of an upper limit of the accidental reactivity insertion. The results of the application of this method to practical cases concerning pressurized water reactors of current design indicate that an upper limit for the reactivity insertion is of the order of a few tenths of a percent in Δk/k. (auth)

3823 (EUR-3617n) KERNENERGIECENTRALE VAN 50 MWe TE DODEWAARD. Jaarverslag 1966. (50 MWe Dodewaard Nuclear Power Plant. Annual Report, 1966). (Gemeenschappelijke Kernenergiecentrale Nederland N.V., Dodewaard). Nov. 1967. Contract 006-63-4 REPN. 132p. (In Dutch). Dep.

The progress made in 1966 in the planning and construction of the nuclear power plant at Dodewaard is presented. The enriched UF_6 supplied by the USAEC is being (11,282 kg) made up into pellets by NUKEM. The fuel elements converted into UO_2 are being fabricated by Philips. Owing to prolonged delays in the fabrication of the pressure suppression tanks and the reactor housing (pressure-suppression system) the original construction schedule had to be altered. These big tanks will later be lowered from above into the now completed reactor building by a crane. The remaining buildings (notably the turbine hall and auxiliary buildings) were completed on time. Preparations are being made for the construction of the biological shield. The main reasons for the delay in the fabrication of the containment were difficulties in the hot-shaping of the vessel bottoms and in the welding processes. After the welding of the reactor pressure vessel and the provision of a stainless-steel lining, there were long delays due to faults in the welded areas of the nozzles. The turbine bedplate was installed. Construction of the generator and main transformer, and installation of the electrical equipment are proceeding according to plan and without complications. The preliminary work for the piping assemblies for the various auxiliary systems have been almost completed. Orders placed up to the end of 1966 amounted to about 90% of the total estimated cost. (auth)

3824 (EURAEC-1873) QUARTERLY REPORT NO. 4 [ON REACTOR COOLING], DECEMBER 15, 1966–MARCH 31, 1967. (Applicazioni e Ricerche Scientifiche, Milan (Italy)). Contract 106-66-12-TEEI(RD). 25p. (EUR-3375). Dep. CFSTI.

Work Performed under United States–Euratom Joint Research and Development Program.

Research on a correlation for the prediction of critical thermal flux under stationary conditions for round ducts and uniform heating is presented. Also, the theoretical study of the phenomenon of burnout crisis, from the hypothesis that one of the major effects causing this crisis is a phenomenon of non-equilibrium between diffusion and re-entrainment velocities, is described. (D.C.C.)

3825 (EURAEC-1899) STABILITY TESTS ON BOILING WATER REACTORS. Quarterly Report No. 10, April 1–June 30, 1967. Schoeneberg, Kraemer (Allgemeine Elektricitaets-Gesellschaft, Frankfurt am Main (West Germany)). Contract 085-66-1-TEED. 49p. (EUR-3391). Dep. CFSTI.

Work Performed under United States–Euratom Joint Research and Development Program.

The evaluation of the measurements made on the four-rod cluster is presented. The stationary measurements of the mixture density, which are significant both for the evaluation of the frequency response curve measurements and for the determination of certain constants of the theoretical model, are listed. In addition the results of various "Heating surface load–local steam bubble component" frequency response curve measurements were collocated. Compared with the measurements on the ring-gap geometry they show a lesser scattering and as a result of a denser series of readings a greater resolution. No essential differences can be detected between the results of the measurements on the ring-gap geometry and on the four-rod geometry. There is also a satisfactory agreement between the theoretically calculated frequency response curves and the experimentally obtained values which is comparable with the agreements obtained on the ring-gap geometry. The alterations to the regulation circuit of the velocity modulator and especially the reconstruction of the semiductor were completed. Test runs showed that the plant is now ready for operations. (auth)

3826 (EURAEC-1900) STUDIES ON CYCLONES FOR STEAM SEPARATION IN BOILING WATER REACTORS. Quarterly Report No. 6, April 1–June 30, 1967. (Allgemeine Elektricitaets-Gesellschaft, Frankfurt am Main (West Germany). Kernenergieanlagen). July 18, 1967. Contract 083-66-1-TEED. 37p. (EUR-3392). Dep. CFSTI.

Work Performed under United States–Euratom Joint Research and Development Program.

Based on the concept of a 600 MW(e) steam separator, an investigation was made on specific questions for constructing this separator. The work accomplished consisted of mixture subdivision and on the required optimization of the dimensions of the single cyclone with the object to shift its ultimate load in the direction of higher throughput capacities. Because of operational reasons, it was impossible to do any work on the test rig during the period in question. Theoretical considerations and the further evaluation of former steam tests were carried out in the meantime in a much more extensive way than had been intended at first. The work on the mixture subdivision dealt in detail with the problems which may arise through the separate forced guiding of the mixture for each row of cyclones and how they can be solved experimentally in the existing air/water test rig. This led to the result that only when an extremely strong water fraction is present in the bordering elements of the reactor core, such as can occur at small partial load drops caused by control rods, the mixture which flows inside the mixture collecting chest is much richer in steam than outside. It must however be assumed that a compensation by turbulence takes place in the mixture collecting chest below the baffle plates, so that all rows of cyclones are uniformly covered. In an air/water test rig, a determination will be made of the necessary height between the core outlet and the baffle plate inlet for obtaining the required compensation. In order to find out by which change of geometrical magnitudes of the individual cyclone a capacity increase can be obtained, the representations of the separating mechanism were studied in detail. The study was based on the already mentioned steam tests in which pressure difference measurements at particularly interesting parts of the cyclone were carried out. The work which is still underway concerns (1) the influence of the uniformity of the mixture inflow on the water ejection and the pressure drop in the steam extraction tube, (2) the form of the steam tail inside the cyclone, (3) the outflow velocity of the steam from the water in

the tail, and (4) the water ejection at partial load. With these data it is hoped to be able to draw conclusions as to the actual critical size of the ultimate load of the cyclone. (tr-auth)

3827 (EURAEC-1912) QUARTERLY REPORT NO. 5 [ON REACTOR COOLING], APRIL 1–JUNE 30, 1967. Technical Report No. 2. (Applicazioni e Ricerche Scientifiche, Milan (Italy)). Contract 106-66-12-TEEI(RD). 31p. (EUR-3396). Dep. CFSTI.

Work Performed under United States–Euratom Joint Research and Development Program.

The vertical motion of a two-phase mixture in round ducts was analyzed under a dispersed annular motion and without heat exchange. Research on the thermal crisis with nonuniform thermal flux in simple geometries and with nonpositive input titres is presented. (D.C.C.)

3828 (EURAEC-1916) POWER DISTRIBUTION MEASUREMENT IN BOILING WATER REACTOR OF GARIGLIANO PLANT, INVOLVING GAMMA SCANNING OF FUEL ELEMENTS AT END OF 1 B CYCLE. Special Report No. 3. Bannella, Roberto; Cammarota, Umberto (Ente Nazionale per l'Energia Elettrica, Rome (Italy)). Aug. 1967. Contract 101-63-11-RDI. 61p. (EUR-3398). Dep. CFSTI.

Work Performed under United States–Euratom Joint Research and Development Program.

Axial power distribution data for the Garigliano plant reactor are obtained during power operation by measuring neutron flux by irradiating probes which can be activated wires located in twenty core positions. Radial power distribution during plant operation is not determined experimentally, but is calculated by computer. When the reactor is shut down, experimental measurement is possible by γ scanning along the fuel elements. The γ scan measurements for the 1B fuel cycle are presented. Computed axial power distributions were also compared with measurements from wire irradiation. (D.C.C.)

3829 (EURFNR-406) PARAMETRIC STUDY OF THE DYNAMIC BEHAVIOUR AND STABILITY OF A STEAM-COOLED FAST REACTOR WITH AN INTEGRATED COOLING CYCLE. Erbacher, F.; Frisch, W.; Huebschmann, W.; Malang, S.; Ritz, L.; Woite, G. (Kernforschungszentrum, Karlsruhe (West Germany)). Oct. 1967. 47p. (EUR-3681.e; KFK-637). Dep. CFSTI.

Work Performed under United States–Euratom Fast Reactor Exchange Program.

In a steam-cooled fast breeder reactor it is possible to produce inherent stability and safety from accidents by the feedback of the cooling cycle on the core. The effects of various parameters on stability and safety are determined for these disturbances: reactivity disturbance, blower failure, load changes, various pipe ruptures, and inadvertent fast unflooding. This results in trends and limits that should be observed in the design of the components and the arrangement of the cooling cycle. It is shown that in particular a cooling cycle integrated in a common pressure vessel produces easily inherent stability and safety of a steam-cooled fast reactor. (auth)

3830 (GEAP-5481) TERMINAL EXAMINATION AND EVALUATION OF EVESR MARK III ROD CLUSTER SUPERHEAT FUEL. Rabin, S. A. (General Electric Co., San Jose, Calif. Advanced Products Operation). June 1967. Contract AT(04-3)-189. 68p. Dep. CFSTI.

The experimental fuel designated Mark III was irradiated as part of the EVESR Nuclear Superheat Fuel Development Program. The initial loading of this fuel in EVESR consisted of four bundles, each composed of four seven-rod clusters. Each bundle contained fuel rods having one cladding thickness—0.008, 0.012, 0.016, or 0.020 inch. Mark III fuel rods were 0.450-inch-diameter solid UO_2 pellets clad with Incoloy-800. The bundles were irradiated in the superheated steam environment for over 2 years and burnups to 9300 MWd/tU. Terminal examinations were performed on selected Mark III fuel elements. The results of the examinations are described. The examinations consisted of visual inspection, dimensional measurements, gamma scanning, fission gas release, burnup, fuel rod sectioning, metallography, and cladding mechanical property tests. Information was thus provided on the effects of design and operating conditions on fuel rod dimensional changes, mechanical integrity, and residual lifetime of the cladding, structural changes in Incoloy-800, general and localized in-pile corrosion of Incoloy-800, and effects of fuel rod spacers on corrosion and wear. No signs of fuel rod failure were evident (except for a bundle which had been undercooled), thus confirming the excellent performance of wire-wrapped, solid cylinder fuel rod clusters in the superheated steam EVESR reactor. (auth)

3831 (JAERI-1145) A PRELIMINARY STUDY OF REACTOR THERMAL CHARACTERISTICS (HEAVY WATER MODERATED CARBON DIOXIDE COOLED REACTOR). Sawai, Sadamu; Tadokoro, Yoshihiro; Seya, Toko (Japan Atomic Energy Research Inst., Tokyo). June 1967. 16p. Dep.

A preliminary study of the reactor thermal characteristics of the heavy water-moderated CO_2-cooled reactor was made and the following conclusions or results were obtained: over 60 kg/cm^2 of the coolant pressure will be considered for the plain surface of the fuel; the coolant temperature rise through the core would be taken over about 250°C considering the blower power required; and some study of the properly designed core shape from the standpoint of the thermal characteristics was made and the range of the thermal design parameters to be considered were obtained. (auth)

3832 (KFK-566) ECONOMIC ASPECTS OF NUCLEAR ENERGY PRODUCTION WITH DIFFERENT THERMAL AND FAST REACTORS AND THE REQUIRED SEPARATIVE WORK CAPABILITY. Gupta, D.; Haefele, W.; Jansen, P.; Seetzen, J. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Angewandte Reaktorphysik). June 1967. 24p. Dep.

Several probable nuclear strategies, for a given nuclear energy growth curve, with different thermal converters, advanced converters and fast breeders with either Pu or U start-up, have been analyzed. The results indicate that the THTR type, regarded as one of the advanced converters, would have some economic and raw material advantage over the LWR type or a two type strategy with LWR and sodium cooled oxide breeder. However, the strategies with steam cooled oxide and Na cooled carbide breeders with ^{235}U startup show definite and significant cost and raw material advantage over any other strategies. These breeders with U start-up represent their own particular type of converters which supply all of the Pu required by them, and with their introduction the importance of high breeding ratio gets considerably reduced. Although U start-up breeders require larger amounts of ^{235}U at the beginning, the total U consumption with these systems over a long period of time would be considerably lower than those with any other thermal or advanced converter systems. The results indicate further that the sodium cooled carbide breeders with ^{235}U start-up have the highest economic potential and the lowest U consumption of the reactor types considered here, and that a simultaneous development effort would be necessary for the steam cooled and sodium cooled breeders because of the different degrees of difficulties associated with each system. (auth)

3833 (NAA-SR-Memo-12540) PIQUA NUCLEAR POWER FACILITY, REACTOR OPERATIONS ANALYSIS PROGRAM. Report 55, June 1967. (Atomics International, Canoga Park, Calif.). 22p. Dep. CFSTI.

Topics discussed include: operation evaluation of PNPF design; examination of Core 1 instrumented fuel element data; coolant chemistry and analysis; and recovery program activities. (D.C.C.)

3834 (NP-16981) ESTUDIO DE PREINVERSION: CENTRAL NUCLEAR PARA LA ZONA DEL GRAN BUENOS AIRES–LITORAL. I. ANEXOS A LOS CAPITULOS 1 Y 3. ANEXO 1A. ORGANIZACION Y ACTIVIDADES DE LA COMISION NACIONAL DE ENERGIA ATOMICA. ANEXO 3A. EL MERCADO ELECTRICO DEL GRAN BUENOS AIRES–LITORAL. (Preliminary Investment Studies: Nuclear Power Plants of the Buenos Aires Region and Coastal Zone. I. Appendix to the Chapters 1 and 3. 1A. Organization and Activities of the National Atomic Energy Commission. 3A. Electrical Market of the Greater Buenos Aires and Coastal Region). (Comision Nacional de Energia Atomica, Buenos Aires (Argentina)). 1965. 132p. (In Spanish). Dep.

The organization and activities of the National Atomic Energy Commission are briefly outlined. The market for electrical power in the Buenos Aires–coastal zone is analyzed, beginning with a historical outline of the growth of the power needs of the region. The possibility of expanding the present power system to fulfill future power requirements is considered. The future power needs are estimated and the results are compared with the results from other studies. (J.S.R.)

3835 (NP-16982) ESTUDIO DE PREINVERSION: CENTRAL NUCLEAR PARA LA ZONA DEL GRAN BUENOS AIRES–LITORAL. II. ANEXOS AL CAPITULO 4. ANEXO 4A. EVALUACION DE RIESGOS DE LA UBICACION. ANEXO 4B. AGUA DE REFRIGERACION. ANEXO 4C. EMPLAZAMIENTO DE LA CENTRAL. (Preliminary Investment Studies: Nuclear Power Plants of the Buenos Aires Region and Coastal Zone. II. Appendix to Chapter 4. 4A. Evaluation of the Dangers of Reactor Locations. 4B. Refrigeration Water). (Comision Nacional de Energia Atomica, Buenos Aires (Argentina)). 1965. 123p. (In Spanish). Dep.

The risks in the location of a nuclear reactor in the Buenos Aires–coastal zone area are evaluated. The requirements on the coolant water are summarized. The characteristics of the water

from the Atucha and Magdalena water purification plants are discussed and compared with the requirements. The possibilities of a closed circuit are considered. The criteria for the site selection are discussed. The natural characteristics of the zone are given. (J.S.R.)

3836 (NP-16983) ESTUDIO DE PREINVERSION: CENTRAL NUCLEAR PARA LA ZONA DEL GRAN BUENOS AIRES-LITORAL. III. ANEXO AL CAPITULO 5. ANEXO 5A. REACTORES DE POTENCIA. (Preliminary Investment Studies: Nuclear Power Plants of the Buenos Aires Region and Coastal Zone. III. Appendix to Chapter 5. 5A. Power Reactors). (Comision Nacional de Energia Atomica, Buenos Aires (Argentina)). 1965. 80p. (In Spanish). Dep.

The characteristics of the four power reactor types—PWR, BWR, CGR, and HWR—are considered in detail. Methods to increase the reactor power after some time in operation are outlined. The personnel needs for operation of power reactors are estimated. Characteristics of breeder reactors are briefly discussed. (J.S.R.)

3837 (NP-16984) ESTUDIO DE PREINVERSION: CENTRAL NUCLEAR PARA LA ZONA DEL GRAN BUENOS AIRES-LITORAL. IV. ANEXOS AL CAPITULO 5. ANEXO 5B. POSIBLE CONTRIBUCION DE LA INDUSTRIA NACIONAL A LA CONSTRUCCION Y OPERACION DE LA CENTRAL NUCLEAR BUENOS AIRES. ANEXO 5C. RECURSOS Y PRODUCCION DE URANIO. ANEXO 5D. URANIO ENRIQUECIDO. ANEXO 5E. PRODUCCION DE GRAFITO Y AGUA PESADA EN LA REPUBLICA ARGENTINA. ANEXO 5F. SEGURIDAD DE REACTORES DE POTENCIA. (Preliminary Investment Studies: Nuclear Power Plants of the Buenos Aires Region and Coastal Zone. IV. Appendix to Chapter 5. 5B. Possible Contribution of the National Industry in Construction and Operation of Buenos Aires Power Plants. 5C. Uranium Production Resources. 5D. Enrichment of Uranium. 5E. Production of Graphite and Heavy Water in the Republic of Argentina. 5F. Reactor Power and Protection). (Comision Nacional de Energia Atomica, Buenos Aires (Argentina)). 1965. 165p. (In Spanish). Dep.

The possible contribution of Argentine industry to the design, construction, and manufacture of electromechanical components, construction of turboalternator, and production of fuel elements and control rods is analyzed. U resources and production in Argentina are considered. The capacity for the preparation of U concentrates and refined products is evaluated. The production costs are estimated. The procuring of enriched U, both from domestic and foreign sources, is discussed. The capacity for the production of graphite of nuclear purity and heavy water in Argentina is evaluated. (J.S.R.)

3838 (NP-16985) ESTUDIO DE PREINVERSION: CENTRAL NUCLEAR PARA LA ZONA DEL GRAN BUENOS AIRES-LITORAL. V. ANEXO AL CAPITULO 7. ANEXO 7A. ECONOMIA DE LAS CENTRALES NUCLEARES. (Preliminary Investment Studies: Nuclear Power Plants of the Buenos Aires Region and Coastal Zone. V. Appendix to Chapter 7. 7A. Nuclear Power Station Economics). (Comision Nacional de Energia Atomica, Buenos Aires (Argentina)). 1965. 128p. (In Spanish). Dep.

The economics of nuclear power stations are analyzed in detail with a discussion of the initial investment, capital costs, utilization factor, operating costs, and production costs. An economic-financing analysis is made. The costs of conventional power stations are outlined and the competitiveness of nuclear power stations is discussed. (J.S.R.)

3839 (NP-16986) ESTUDIO DE PREINVERSION: CENTRAL NUCLEAR PARA LA ZONA DEL GRAN BUENOS AIRES-LITORAL. VI. ANEXO AL CAPITULO 7. ANEXO 7A. ECONOMIA DE LAS CENTRALES NUCLEARES (TABLAS). (Preliminary Investment Studies: Nuclear Power Plants of the Buenos Aires Region and Coastal Zone. VI. Appendix to Chapter 7. 7A. Nuclear Power Station Economics (Tables)). (Comision Nacional de Energia Atomica, Buenos Aires (Argentina)). 1965. 67p. (In Spanish). Dep.

The composite picture of the income and capital expenditures is tabulated for PWR, BWR, HWR, and CGR reactors of 300 and 500 Mw, and for conventional power stations of the same capacity. The income and expenditures for these power stations are tabulated. The capital costs for each reactor type are also tabulated. (J.S.R.)

3840 (NP-16988) ESTUDIO DE PREINVERSION: CENTRAL NUCLEAR PARA LA ZONA DEL GRAN BUENOS AIRES-LITORAL. (Preliminary Investment Studies: Nuclear Power Plants of the Buenos Aires Region and Coastal Zone). [Volume] II. (Comision Nacional de Energia Atomica, Buenos Aires (Argentina)). 1965. 159p. (In Spanish). Dep.

The characteristics of the four types of reactors considered—PWR, BWR, GCR, and HWR—are tabulated and discussed in detail. The contribution of the Argentine industry to the construction and operation of a nuclear power plant is considered. The characteristics of the fuels for each of the reactor types are discussed. A program is outlined for execution of the project. The legal aspects of the project are studied synthetically. The economic aspect of the reactor project are studied with a consideration of the installation, operational, fuel, and production costs. The financing of the project is discussed. The nuclear reactor project is evaluated with respect to the reactor type. An economic comparison is then made among the reactor types and with a conventional thermal power plant. The intangible benefits from the installation and operation of a nuclear power plant are analyzed. (J.S.R.)

3841 (NP-16989) ESTUDIO DE PREINVERSION: CENTRAL NUCLEAR PARA LA ZONA DEL GRAN BUENOS AIRES-LITORAL. (Preliminary Investment Studies: Nuclear Power Plants of the Buenos Aires Region and Coastal Zone). [Volume] I. (Comision Nacional de Energia Atomica, Buenos Aires (Argentina)). 1965. 92p. (In Spanish). Dep.

A study was made on the feasibility of providing economically competitive nuclear power plants for the Buenos Aires-coastal zone area. The technical, economic, financial, political, legal, social, and sanitation problems in the installation and operation of a power reactor are examined. The study was based on power ranges from 300 to 500 Mw and on the GCR, HWR, PWR, and BWR reactor types. In the first volume a broad outline is given of the area of study. The characteristics of the Buenos Aires-coastal zone were outlined. The power needs of this area at the present and in the near future are outlined. The factors to be used in the selection of the power and location of the reactor are derived. (J.S.R.)

3842 (NUS-409) REACTOR OPERATION'S SAFETY ANALYSIS MONTHLY REPORT NO. 26, AUGUST 1 TO AUGUST 31, 1967. (NUS Corp., Washington, D. C.). Contract AT(11-1)-651; Subcontracts No. 4 and 5. 63p. Dep. CFSTI.

For Rural Cooperative Power Association, Elk River, Minn.

Secondary system and turbine air ejector activities, plant radiation levels, and the performance of the Off-Gas System Recombiner are summarized for the report period. Reactor coolant ^{131}I fission product concentration and coolant water gross beta activity are reported. The method and results of measurements on the degree and characteristics of bowing in fuel rods are presented. The maximum bow inferred from rod-to-rod gap measurements in 12 fuel assemblies was 0.150 inch. A review of the meteorological data collection program indicated that rework and relocation of the anemometer sensors is necessary. The feasibility of converting the evaporator handhole closures from welded caps to bolted flanges was investigated and found to offer no clear-cut economic advantage. A request authorizing a change in the containment leakage rate limit and a revised containment testing program was approved. (H.D.R.)

3843 (NUS-411) REACTOR OPERATION'S SAFETY ANALYSIS MONTHLY REPORT NO. 27, SEPTEMBER 1 TO SEPTEMBER 30, 1967. (NUS Corp., Washington, D. C.). Contract AT(11-1)-651; Subcontracts No. 4 and 5. 75p. Dep. CFSTI.

For Rural Cooperative Power Association, Elk River, Minn.

An operations history for the Elk River Reactor for the month of September is given. Secondary system activity levels are shown; area radiation levels are discussed. Primary coolant gross ^{131}I levels and gross β activity are shown. A summary of fuel element failures vs time and estimates of core reactivity lifetime are presented graphically. Status of bowed fuel elements is tabulated; cycle summaries for cycles 3, 4, and 5 are given. Changes in operating procedures are included. (M.L.S.)

3844 (ORNL-4173) WATER CHEMISTRY IN PRESSURIZED AND BOILING WATER POWER REACTORS. Jenks, G. H.; Griess, J. C. (Oak Ridge National Lab., Tenn.). Nov. 1967. Contract W-7405-eng-26. 55p. Dep. CFSTI.

A literature survey of the corrosion behavior of materials in aqueous reactor environments as it relates to the need for water purification and a discussion of radiolytic gas generation and recombination in a boiling-water TLPR are presented. (auth)

3845 (PRWRA-117) REACTOR OPERATIONS AT THE BONUS PLANT. Monthly Report No. 8, August 1967. (Puerto Rico Water Resources Authority, San Juan). Contract AT(40-1)-2672. 22p. (WRA-B-67-18). Dep. CFSTI.

Topics discussed include: operation schedule; shutdown record and analysis; coolant flow pressure profile in reactor; control rod drop testing; maintenance; and radiation monitoring of environment. (D.C.C.)

3846 (TID-24085) SAFETY STANDARDS, CRITERIA, AND GUIDES FOR THE DESIGN, LOCATION, CONSTRUCTION, AND

OPERATION OF REACTORS. III. TECHNICAL SAFETY GUIDE. REACTOR CONTAINMENT LEAKAGE TESTING AND SURVEILLANCE REQUIREMENTS. (Division of Safety Standards (AEC), Washington, D. C.). Dec. 15, 1966. 14p. Dep. CFSTI.

Four classes of tests to be used during the service life of containment systems are discussed. The four classes include: Class A tests for overall integrated leakage rate measurements of the containment system under the "as is" service condition, at the time of the test; Class B tests for local leak detection tests of containment components which penetrate, or seal the boundary of the containment system; Class C tests for individual local operability and leakage of containment isolation valves; and Class D tests for individual operability tests under Class A requirements for containment leakage under post-accident conditions. (D.C.C.)

3847 (TID-24131) GARIGLIANO NUCLEAR POWER PLANT OPERATION REPORT FOR THE 2nd QUARTER OF 1967. (Ente Nazionale per l'Energia Elettrica, Rome (Italy)). June 30, 1967. 23p. Dep. CFSTI.

Operations at the Garigliano Power Reactor from April 1 to June 30, 1967 are described. Topics discussed include: power curves; fuel burnup; core pressure measurements; core description; radiation monitoring; coolant contamination; reloading; and maintenance. (D.C.C.)

3848 (WAPD-TM-672) CALCULATIONAL METHOD FOR THERMAL DISADVANTAGE FACTOR (LWB-LSBR DEVELOPMENT PROGRAM). Buslik, A. J. (Bettis Atomic Power Lab., Pittsburgh, Pa.). Sept. 1967. Contract AT(11-1)-Gen-14. 20p. Dep. CFSTI.

A rapid method of calculation of the thermal disadvantage factor for a lattice cell consisting of a fuel rod, clad, and water is presented. The method permits representation of the actual cell geometry and includes the effects of spectral hardening in the fuel. It consists of a series of one-energy spatial calculations using the Sauer method followed by a homogeneous spectral calculation. Numerical comparisons between this calculational method and much more elaborate 36-multigroup Monte Carlo calculations are made, and good agreement is obtained. (auth)

3849 (WAPD-TM-673) VARIATIONAL CALCULATION OF COMPLEX NATURAL MODES OF XENON OSCILLATION (LWB-LSBR DEVELOPMENT PROGRAM). Buslik, A. J.; Weinreich, W. A. (Bettis Atomic Power Lab., Pittsburgh, Pa.). Sept. 1967. Contract AT(11-1)-Gen-14. 14p. Dep. CFSTI.

A variational calculation of the complex natural modes of Xe oscillation (p-modes) is presented. The I and Xe components of the p-modes are eliminated before the functional is set up, eliminating the need for trial functions for these variables. The eigenvalues p are determined by the solution of a polynomial equation. When used in conjunction with a single μ-mode trial function, an improvement in the usual μ-mode formalism is produced, since fast fission production of Xe can be taken into account more exactly. (auth)

3850 (ZJE-1-67) THE FIRST CZECHOSLOVAK NUCLEAR POWER PLANT AND PERSPECTIVES OF NUCLEAR POWER IN CZECHOSLOVAKIA. Hulovec, Jan (Skoda Works, Pilsen (Czechoslovakia)). 1966. 9p. Dep.

A description of the Czechoslovak nuclear power station A-1 is given. Industrial cooperation in the nuclear field is emphasized. Predictions for the use of nuclear energy in Czechoslovakia are made. A preliminary description of station A-2, which is in the planning stage, is given. (M.L.S.)

3851 RELOADING OF BRED FUELS IN Th REACTORS. Barthold, W. P. (Kernforschungsanlage, Juelich, Ger.). Atomwirtschaft, 11: 598(Dec. 1966). (In German).

The reloading of bred fuels in power reactors presents a series of new problems. Using a Th reactor as an example it was shown that the economy of this system depends to a very great degree on cheap and rapid reprocessing and refabrication. High breeding rates and specific powers can be used when the bred fuel can be obtained and reprocessed rapidly and cheaply. When it is installed in a reactor type of 15,000 MWe, as is expected first in 1980 for the EURATOM countries, the refabrication and reprocessing costs 12 to 22% of the current production costs. (tr-auth)

3852 GAS-COOLED REACTORS WITH A NOVEL BOILER CONCEPT. Churchill, G. F. Neue Tech., 9: 205-8(Oct. 1967).

Descriptions of the basic features and concepts of a typical 500 MW AGR with an integral reactor unit are presented. The descriptions include: prestressed concrete pressure vessels enclosing the reactor core, boilers, gas circulators, and ductwork; reactor core, reflector, and radiation shields; and refueling apparatus. (D.C.C.)

3853 REPORT ON THE RELATIONS WITH NATIONAL RESEARCH AGENCIES. Salvetti, Carlo. Com. Naz. Energ. Nucl., Notiz., 13: No. 7, 25-36(July 1967). (In Italian).

The cooperation and collaboration between national agencies and industry in Italy in order to assure a continuing evolution of nuclear technology by industry are outlined. The criteria for the selection of research programs by the CNEN are outlined. The implementation of these criteria is illustrated by a description of the reactor development programs and the nuclear fuel cycle studies. In reactor development programs the design of the CIRENE reactor, fuel element test programs for fast reactors, naval propulsion program, and the organic reactor for the production of industrial gases are the examples cited. In the fuel cycle program there has been collaboration on the fabrication of fuels and the regeneration and the recycling of fuels. The EUREX and PCUT programs for the processing of nuclear fuels are described. The mechanism for the transfer of know-how from the national centers to industry is outlined. (J.S.R.)

3854 EARTHQUAKE-PROOF [ADVANCED GAS COOLED REACTORS] FOR EXPORT. Brierley, G. (United Kingdom Atomic Energy Authority, Risley, Eng.). Reactor, 6: 12-14 (Sept. 1967).

Ability of the AGR design to withstand earthquakes and ground faults is briefly considered, and the advantages of the concrete pressure vessel and integral primary circuit are discussed. (UK)

3855 THE A.G.R.: A WELL-PROVEN POWER PLANT FOR EXPORT. Dent, K. H. (United Kingdom Atomic Energy Authority, Risley, Eng.). Reactor, 6: 8-11(Sept. 1967).

The advantages of the design discussed include the proven reliability of gas-cooled reactors, the high efficiency of the modern turbo-generators which can be used, and the exceptional safety, which allows stations to be built close to populated industrial areas. (UK)

3856 FLOW REDUCTION OF RESEARCH REACTORS. Costa, J.; Courtaud, M.; Elberg, S.; Lafay, J. (CEN, Grenoble, France). Bull. Inform. Sci. Tech. (Paris), No. 117, 89-103 (July-Aug. 1967). (In French).

The critical heat flux limiting the power of low pressure water cooled reactors is generally a consequence of the flow reduction occuring in the hot channels of the core. The mechanism of this phenomena is developed and a description is given of the out-of-pile loops on which its characteristic values are measured. Some results are presented and the influence of main parameters is shown. (auth)

3857 FAST BREEDER REACTORS. WHEN? WHY? HOW? Vendryes, Georges; Perrin, Francis (Commissariat a l'Energie Atomique, France). Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), No. 66, 39-45(July-Aug. 1967). (In French).

The probability that fast neutron breeder reactors can be developed to be competitive with other types of power reactors and the availability of Pu are two factors that will lead to the development of fast breeders. The difficulty in the development of economic fast reactors is outlined. The construction of prototype in the nuclear countries is outlined. The advantageous position of the European countries in the development of fast reactors in comparison with those of the United States is discussed. (J.S.R.)

3858 CENTRIFUGAL PUMPS FOR NUCLEAR POWER STATIONS. Vienne, L.; Vuckovic, M. ACEC (Ateliers Constr. Elec. Charleroi) Rev., No. 2, 23-30(1967).

The motor-pump sets in the primary circuit of the Ardennes Nuclear Power Station and especially the sets of quite special construction in the primary closed loops, those for cooling auxiliary equipment, evacuation of heat and safety injection, and also the sets in the normal side of the power station such as those for circulation and extraction from the condenser and those which feed the heat exchangers are described. (auth)

3859 ELASTIC-PLASTIC BEHAVIOUR OF THIN TUBES SUBJECTED TO INTERNAL PRESSURE AND INTERMITTENT HIGH-HEAT FLUXES WITH APPLICATION TO FAST-NUCLEAR-REACTOR FUEL ELEMENTS. Bree, J. (Heriot-Watt Univ., Edinburgh). J. Strain Anal., 2: 226-38(July 1967).

A sealed reactor fuel can when subjected to sufficiently high thermal stresses in the presence of an internal pressure will yield plastically. A simple model of the can is used to show that the plastic strains so produced may cause ratchetting or plastic cycling as the temperature gradient across the can wall cycles because of startup and shutdown of the reactor. On the assumption that creep is negligible, approximate criteria are derived for the onset of ratchetting and plastic cycling, simple expressions are obtained for the plastic strains incurred by each cycle, and failure of the can due to the above mechanisms is discussed

both for work-hardening and non-work-hardening material. Consideration is also given to the effect of stress relaxation due to creep when the mean temperature of the can is sufficiently high to cause complete relaxation of the thermal stress while the reactor is at power, creep being ignored while the reactor is shut down. Under these conditions it is found that the criterion for ratchetting is simply the criterion for plastic yielding during the first temperature cycle. Finally, it is shown that the results obtained from the simple model also hold, with minor modifications, for the similar problem of a thin spherical shell subjected to an internal pressure and a temperature gradient across the shell wall which is cycled. A discussion of the accuracy of the results obtained from the simple model when applied to a thin can is given. (auth)

3860 REFUELLING MACHINE FOR LIQUID COOLED POWER REACTORS WITH VERTICAL PRESSURE VESSEL. Cesari, Franco (Comitato Nazionale per l'Energia Nucleare, Rome). Nucl. Eng. Design, 6: 236-42(1967).

The refueling equipment described is particularly indicated for those liquid coolants whose toxicity renders the uncovering of the reactor vessel difficult; it can be applied to vertical nuclear vessels with upper removable cover. The refueling is accomplished during reactor shutdown by means of shielded cask, rotating plug, fuel element guide tube and fuel grabbing device. (auth)

3861 THIRD FORATOM CONGRESS. SESSION I. FAST REACTOR DEVELOPMENT OBJECTIVE. GENERAL REACTOR CHARACTERISTICS AND FUEL REQUIREMENTS. Searby, P. J. (United Kingdom Atomic Energy Authority, Eng.). Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), No. 66, 5-20(July-Aug. 1967). (In French).

The two principle reasons for the development of fast reactors for the industrial production of electricity are the belief that this reactor offers the prospect of the most substantial economy with respect to electrical production, and the guarantee that this reactor gives against the scarcity of nuclear fuel in the foreseeable future. The emphasis at the present in the design of fast reactors is on Na-cooled reactors. The calendar set up by the various FORATOM countries for the construction and industrial use of fast reactors is briefly outlined. The probable characteristics of the first commercial fast reactors are described with respect to the initial charge in fissionable material, specific power, burnup, recharging, Pu loss, doubling time, and the fuel material needs. The foreseeable problems to be solved in the development of this reactor type are tabulated. (J.S.R.)

3862 OPTIMAL SHUTDOWN CONDITIONS FOR SHORT-DURATION OPERATIONS OF A REACTOR. Artamkin, V. N.; Babikova, L. P.; Fedorenko, R. P. At. Energ. (USSR), 23: 143-5(1967). (In Russian).

A calculation method was developed in order to determine reactor shutdown conditions which, for a shortest control time T, will allow a certain desired Xe concentration at the moment of the shutdown. The best control conditions for fast operation were solved by setting the boundary conditions $[0 \leq F(t) \leq F_{max}]$ for the control and $[x^0(t) \leq x^* \text{ for } 0 \leq t \leq T]$ for the phase variable. Such a control is desirable if it is intended to carry out work with a shutdown reactor for a period exceeding the time at which the reactor falls to the level of the iodine well. At the start, $F(t) = 0$ and the Xe concentration increases rapidly. When the Xe concentration reaches the maximum permissible level, the flow changes as to maintain that concentration. During the last stage, $F(t) = F_{max}$. Various shutdown conditions were graphically represented. (TTT)

3863 THE STARTUP OF THE NUCLEAR POWER PLANT IN ARDENNES. Doyen, R. Electricite, No. 131, 23-34(June 1967). (In French).

The prestartup and startup operation of the Ardennes nuclear power plant are described. The test and measurements made during this period are reviewed with emphasis on the reactivity measurements and the internal instrumentation of the core. The production costs of electricity and public safety are briefly considered. (J.S.R.)

3864 DISTILLATION METHODS FOR DESALINATION. Huyghe, Jean; Vignet, Paul. Ind. At., 11: No. 9-10, 59-69 (1967). (In French).

After briefly recalling the advantages of using nuclear energy for large-scale removal of salt from sea water, the principle underlying the two processes of distillation traditionally employed by plants with a large capacity: the process using successive condensations and the multiple-effect drop process is explained. The chief characteristics of the water-treating plants depending on the processes coupled with a nuclear reactor of a French network of the S.L.E. type are presented. The mixed powerhouses arranged in this way would supply about 500,000 tons of distilled water per day and would have an electrical power in the order of 250 MW. The various research projects undertaken at the Grenoble plant of the CEN to improve the techniques of distillation in the domain of prevention of saline deposits and in that of heat transfers and the outflow of two-phase fluids (water-vapor mixtures) are listed. (auth)

3865 IDENTIFICATION OF OPERATORS IN THE REACTOR PHYSICS. Kovanic, Pavel (Kernforschungsinstitut, Czechoslovakian Academy of Sciences, Rez). Atomkernenergie, 12: 404-8 (1967). (In German).

The estimation of unknown parameters of the operator of a black-box based on the treatment of experimental input- and output functions can be economically performed by means of the method of static programming. In this way, some problems of experimental reactor physics can be both formulated and solved from a new point of view. As the example of practical application of this approach the determination of the reactor buckling from the measured neutron space distribution is shown. (auth)

3866 ECONOMIC AND TECHNICAL PROBLEMS CONCERNED WITH THE COOPERATION AMONG N.A.T.O. COUNTRIES IN NUCLEAR ENTERPRISES FOR PEACE. PART IV. di Loreto, Angelo (Univ., Rome). Riv. Ing. Nucl., 4: 1221-59 (Nov.-Dec. 1966).

Present power needs for European countries are shown in comparison to power requirements on a yearly basis from 1907. Fossil fuel costs are presented for the same time period and compared to existing supplies. Nuclear power plants for European countries are described on a cost comparison with power output. Present and planned programs for nuclear power applications in Europe are described. (D.C.C.)

3867 MONITORING OF RADIOACTIVE GASEOUS EFFLUENTS. della Rocca, Carlo. Riv. Ing. Nucl., 4: 1203-19(Nov.-Dec. 1966). (In Italian).

Gaseous radioactivity transport from the effluent of the Garigliano Power Reactor is discussed. Methods used for continuous monitoring of the effluent are presented. Isotopic analyses of discharged gases are given. Occurrences of gaseous releases are tabulated. An analysis of the fission product distribution is given. (M.L.S.)

3868 REGULATION OF ORGANIC FLOW IN A NUCLEAR REACTOR. Raimondi, Tommaso (Univ., Palermo, Italy). Riv. Ing. Nucl., 4: 1191-1202(Nov.-Dec. 1966). (In Italian).

Theoretical and practical considerations of the PRO reactor design are presented. The organic cooled systems are discussed in detail. Fluid flow characteristics are determined with respects to automatic valving and transmission. Regulation of fluid flow in the heat exchanger is discussed. (M.L.S.)

3869 LOEFFLER PRINCIPLE AND REACTOR COOLING. Streeton, D. F. (Suiselectra AG, Basel). Eng. Boiler House Rev., 82: 291-4(Oct. 1967).

The history of the Loeffler principle and its application to fossil fuel firing are reviewed. When applied to steam cooled power reactors the versatility of the principle has much attraction. Steam cycles discussed are the straight cycle, direct reactor reheat cycle, indirect reheat cycles with condensing and non-condensing reheaters, and combined reheat dual pressure cycle. (UK)

3870 PROBLEMS CONNECTED WITH THE DYNAMICS OF A REACTIVITY INCIDENT OF CONSIDERABLE PROPORTIONS: IMPACT SHOCK IN A WATER REACTOR PRESSURE VESSEL DUE TO THE EXPULSION OF A CONTROL ROD. Eletti, G. F.; Zambrini, R. Riv. Ing. Nucl., 25: 1287-90(Jan.-Feb. 1967). (In Italian).

A discussion of an analytical treatment of water reactor excursion calculations is presented. The consequences of a reactivity incident, based primarily on shock generation in the pressure vessel, are discussed. (M.L.S.)

3871 THE NUCLEAR CENTER OF GUNDREMMINGEN. EMERGENCY ENERGY IN THE NUCLEAR CENTER OF GUNDREMMINGEN. THE AEG BOILING WATER REACTORS. Jaerschky, R.; Leistner, B.; Zwoenitzer, D.; Bruechner, H. J.; Taurit, R. Elettrotecnica, 53: 563-8(Aug. 1966). (In Italian).

A description of the Gundremmingen Nuclear Center is given. Included is general plant schematic, a detailed schematic of the reactor vessel with associated cooling and steam systems, a cutaway drawing of the physical structure of the reactor, and an instrumentation and electrical schematic. Each system is summarized. (M.L.S.)

3872 APPARATUS FOR HANDLING THE FUEL ELEMENTS IN A NUCLEAR REACTOR. Delisle, Jean Paul (to Commissariat a l'Energie Atomique). British Patent 1,089,559. Nov. 1, 1967. Priority date Aug. 31, 1965, France.

The design of a fuel handling apparatus for sodium-cooled reactors is presented. The fuel handling apparatus has an arm connected by a horizontal pivot pin to a vertical support column which rotates about its axis in a plug mounted in the reactor cover. A second arm pivoted to the free end of the first arm has a fuel-element grab pivoted to the second arm free end. (D.C.C.)

3873 NUCLEAR REACTOR CORES. Seddon, James Walter; Kline, Robert Allen (to Nuclear Power Plant Co., Ltd. AEI-John Thompson Nuclear Energy Co., Ltd.). British Patent 1,089,391. Nov. 1, 1967. Filed Jan. 16, 1964.

The configuration of a reactor core with solid neutron moderator material is presented. The solid moderator blocks are keyed together by slots on the outside surfaces. Other slots are shown which serve as stress relievers from radiation effects. (D.C.C.)

3874 IMPROVEMENTS IN OR RELATING TO MODERATOR STRUCTURES FOR HETEROGENEOUS NUCLEAR REACTORS. Rouge, Pierre; Vivien, Jean (to Commissariat a l'Energie Atomique). British Patent 1,090,587. Nov. 8, 1967. Priority date Mar. 17, 1965, France.

The configuration of solid moderator structures for heterogeneous reactors is presented. The configuration requires a plurality of axially aligned bars or blocks of moderator material with some bars containing centrally located fuel elements or control rods and some bars without central bores to serve as strength material. The bars also contain at least one helical slot coaxial with the bar cut in the surface of the bore and also cut in the external surface of the bar. (D.C.C.)

3875 NUCLEAR REACTOR. (to Commissariat a l'Energie Atomique). French Patent 1,459,232. Oct. 10, 1966. Filed Oct. 6, 1965.

The reactor is cooled by the circulation of a cooling fluid in channels, the section of which is constant throughout their length, each channel being occupied by a train of fuel elements. The fuel elements consist of an external tubular jacket of moderating material and a real fuel element maintained in a boring of the jacket in a way to permit the passage of the cooling gas. The jacket of the terminal element, at least, situated at the opposite end of the channel by which the element is unloaded limits a section of the passage for the coolant to a greater extent than the jackets of the standard elements, occupying the portion of the channel nearest the end by which unloading is effected. The external wall of the jackets is of constant diameter over the whole length of the channel, while the boring of the terminal element has a greater diameter than that of the others. The object is to limit the aerodynamic forces exerted on the elements not only when in position but also during the course of unloading. (IIB)

3876 CONTROL MECHANISM FOR CONTROL RODS. (to Commissariat a l'Energie Atomique). French Patent 1,458,620. Oct. 3, 1966. Filed Sept. 29, 1965.

The mechanism is used in liquid metal-cooled reactors and comprises gripping organs for the head of the control rod, and a control stem for these organs in a coaxial transfer tube. Means are provided outside the reactor vessel for the transfer of the tube through the vessel. A sealing labyrinth joint is disposed between the tube and and the vessel and a metallic bellows between the tube and the control stem. The tube includes openings, allowing free circulation of the liquid metal through the tube while guiding organs for the control stem having a point contact with the latter. The tube may be guided in its transfer by a fixed external tube having openings for the free circulation of the liquid from the vessel. (IIB)

3877 PRESTRESSED CONCRETE PRESSURE VESSEL FOR NUCLEAR REACTORS. (to Commissariat a l'Energie Atomique). French Patent 1,364,660. May 19, 1964. Filed May 8, 1963.

The vessel comprises a gas-tight steel membrane, which serves as a lining for a chamber which is delimited by the pressure vessel and through which circulates a gas under pressure for the purpose of cooling the reactor. The pressure vessel consists of a cylindrical shell, two bases which are separate from the shell and each disposed at one end of the shell, and prestressing cables for the purpose of assembling the shell and the bases. The cylindrical shell consists of an outer zone of "active concrete" which is alone traversed by the cables and an inner zone of "passive concrete" which is subdivided by transverse and axial slots formed in the inner zone into a plurality of segments. The inner zone serves as heat insulation for the concrete of the outer zone and also to transfer to the outer zone the pressure forces exerted by the coolant gas on the gas-tight lining membrane. (IIB)

Marine and Portable Power Reactors

3878 (TRG-Report-1500) MARINE NUCLEAR REACTORS. A Lecture Given at a Branch Meeting of the Institution of Mechanical Engineers, Barrow, 1 December 1966. Rigg, S.; Kay, J. (United Kingdom Atomic Energy Authority, Risley (England). Reactor Group). 1967. 32p. Dep. CFSTI. UK 4s. 6d.

The current state of progress made internationally in the development of nuclear power for marine propulsion units is reviewed. Economic factors influencing this development are emphasized; the technical factors involved are outlined. A typical pressurized water reactor incorporating a burnable-poison core and integral heat exchanger suitable for marine use is described, and the main parameters for a 71 MW(t) reactor are listed. The main features and philosophy of the design and development potential are discussed. The effects of the particular requirements for the use of nuclear propulsion units on the design of the ship and its machinery, and economic comparisons with conventional methods of propulsion for various marine applications are also considered. (auth)

3879 ISPYTANIYA PRIVODOV UPRAVLENIYA SUDOVYKH YADERNYKH REAKTOROV. (Examination of the Control Drive of Maritime Nuclear Reactors). Maslenok, B. A. Leningrad, Izdatel'stvo Sudostroenie, 1967. 165p.

Standard tests of control drives of maritime nuclear reactors are reported. The basic requirements in the construction of control drives are summarized. The different types of control drives and the characteristics of their testing are examined. The parameters, characterizing the reliability of the drive construction, are analyzed. Test methods and experimental determination of the coefficients characterizing the reliability are reported. Attempts are made to systematize the results of experimental studies on control drives carried out in different countries. (tr-auth)

Rocket and Space Reactors

Refer also to abstract 2448.

3880 (NAA-SR-12504) THE DISASSEMBLY AND POST-OPERATION COMPONENT EXAMINATION OF THE SNAP 10A FS-3. Dooley, J. P.; Beall, J. P. (Atomics International, Canoga Park, Calif.). Sept. 15, 1967. Contract AT(04-3)-701. 70p. Dep. CFSTI.

The SNAP 10A Flight System was operated as a ground demonstration test of the SNAP 10A system. After operating continuously for over 10,000 hr the test was terminated, the system was disassembled, and critical system components were examined to determine the effect of the system operating environment. The disassembly of the system and the postoperation examination of the system components, with the exception of the fuel, are described. (auth)

3881 (NASA-CR-72234(Vol.1)) CAVITY REACTOR CRITICAL EXPERIMENT. VOLUME 1. Final Report. Pincock, G. D.; Kunze, J. F. (General Electric Co., Idaho Falls, Idaho. Nuclear Materials and Propulsion Operation). Sept. 6, 1967. Contract C-67747-A. 380p. Dep. CFSTI.

A series of experiments were conducted at the Idaho Test Station on a large "cavity" reactor consisting of a cavity 183 cm in diameter of 122 cm long surrounded by 91 cm of heavy water. The cavity was fueled with uranium-235. Measurements were made on various configurations, including such variations as fuel diameter and shape, beryllium baffles in the reflector and insertion of various structural and operating materials characteristic of a nuclear rocket reactor. 11 references. (auth)

3882 POSSIBILITIES OF THE USE OF NUCLEAR ENERGY SUPPLYING PLANTS IN SPACE FLIGHT. Rasch, W. (Institut fuer Strahlantriebe, Brunswick). Atompraxis, 13: 397-400(1967). (In German).

In the energy range of 5 to 100 kW(e), thermionic reactors have proved particularly advantageous. They may be installed in communication and television satellites as well as in interplanetary probes. In connection with electrical propulsion for transfer orbits, higher payload ratios can be achieved than with chemical power. A television satellite for direct receiving and a Jupiter probe are outlined. (auth)

3883 SNAP 8 REACTOR BEARING DEVELOPMENT. Kellogg, L. G.; Dewart, W. G. ASLE (Amer. Soc. Lubric. Eng.) Trans., 9: 325-35(1966).

A four-phase program for development of SNAP 8 reactor bearings is reviewed. Low-speed, oscillating bearings, journal bushing

type and reflector control-drawn bearing, are designed to provide low-friction self-lubrication at 1150°F in the environment of a nuclear reactor operating in space. The program includes study and screen testing of bearing materials for static adhesion and in sliding couple; fabrication and testing of bearing materials in prototype design and optimizing and testing of final designs for reactor ground test in poor vacuum (10^{-5} torr) and in simulated space, ultrahigh clean vacuum (10^{-9} torr). Test facilities and techniques are described and results of static adhesion and sliding friction studies are summarized for 120 material couples. Results of shock and vibration studies on prototype bearings show structural integrity of bearings. Mechanical carbon-graphite in a sliding couple with Al_2O_3-coated metals is shown to be a low-friction, low-wear bearing material. Sodium silicate-bonded MoS_2 and graphite lubricants no Al_2O_3 surfaces provide friction coefficients of less than 0.2 at temperatures from room ambient to 1100°F in vacuum. Oxidation of bearing surfaces is immeasurable after 5000 hr at 1150°F in a vacuum of 1×10^{-5} torr. 9 ref. (auth)

Research and Test Reactors and Critical Assemblies

Refer also to abstracts 2272, 2324, 2388, 2591, and 2707.

3884 (AECL–2763) RADIATION ENERGY ABSORPTION IN WR-1: MEASUREMENTS AT LOW POWER. Tomlinson, M.; Atherley, R. M.; Unruh, W. G.; Boyd, A. W. (Atomic Energy of Canada Ltd., Pinawa (Manitoba). Whiteshell Nuclear Research Establishment). Aug. 1967. 26p. Dep. CFSTI. CAN $1.00.

Radiation dosimetry measurements were performed in the centre of WR-1 reactor fuel assemblies to determine rates of energy absorption from fast neutrons and γ rays. The detectors used were γ-ray sensitive ion-chambers, cyclohexane chemical dosimeters, Ni wires for fast neutron flux, and Co wires for thermal neutron flux. Relative to a fast neutron flux of 1×10^{14}/cm²-s, dose rate values in the center of the fuel assemblies were: total dose rate in cyclohexane (C_6H_{12}) = 7.5 ± 0.5 W/g; γ-ray contribution to dose rate in cyclohexane = 1.76 ± 0.09 W/g; and thermal neutron flux 0.44×10^{14}/cm²-s. Computer calculations gave a fast neutron flux value in agreement with measured values, and gave information on relative neutron energy absorption rates. The results are used to estimate the rates of energy absorption in the organic coolant of the WR-1 reactor. (auth)

3885 (AEEW-R–502) MEASUREMENTS OF MATERIAL BUCKLING AND DETAILED REACTION RATES IN A SERIES OF LOW ENRICHMENT UO_2 FUELLED CORES MODERATED BY LIGHT WATER. Brown, W. A. V.; Fox, W. N.; Skillings, D. J.; George, C. F.; Burholt, G. D. (Atomic Energy Establishment, Winfrith (England)). Sept. 1967. 129p. Dep. CFSTI. UK 19s. 0d.

Measurements were made in the DIMPLE reactor on a number of regular, 3% enriched, UO_2-light water lattices. Detailed reaction rate measurements were made in addition to the material bucklings, using moderator to fuel volume ratios from 3.16 to 0.78. One assembly was heated to 90°C; in addition, the coolant density change on heating to 250°C was simulated by inserting aluminium void pins into the lattice. (UK)

3886 (ANL–5715(Add.)) ADDENDA TO THE HAZARDS SUMMARY REPORT ON THE OXIDE CRITICAL EXPERIMENTS. Plumlee, K. E.; Craig, D. S.; Dates, L. R.; Juliano, J. O.; Kelber, C. N.; Lennox, D. H. (Argonne National Lab., Ill.). Mar. 1967. Contract W-31-109-eng-38. 65p. Dep. CFSTI.

Projects discussed include: the AHFR critical assembly experiments; the High Conversion Critical Experiments; and the internal superheater critical experiments. Separate abstracts are presented for each of the three reports included. (D.C.C.)

For abstracts of individual papers see: 3887–3889.

3887 (ANL–5715(Add.), pp 3-20) HAZARDS SUMMARY REPORT ON AHFR CRITICAL EXPERIMENTS. Addendum I. Kelber, C. N.; Lennox, D. H.; Plumlee, K. E. (Argonne National Lab., Ill.).

A description of the 100 MW Argonne High Flux Reactor (AHFR) is presented. In hazards analysis for the critical assembly the maximum reactivity insertion that can be controlled by a BORAX-type shutdown without fuel-plate melting is determined. Also, the energy and fission-product release for BORAX-type of excursion with fuel-plate melting is examined. (D.C.C.)

3888 (ANL–5715(Add.), pp 21-42) HAZARDS SUMMARY REPORT ON HIGH CONVERSION CRITICAL EXPERIMENTS. Addendum II. Craig, D. S.; Dates, L. R.; Plumlee, K. E. (Argonne National Lab., Ill.).

Descriptions of the High Conversion Critical Experiments (Hi-C) assembly and fuel-pins are presented. The criticality requirements and conversion ratios in high-conversion cores are determined with respect to influences of spectral hardening of flux and resonance absorption. Measurements of neutron density changes with time during excursions are presented. (D.C.C.)

3889 (ANL–5715(Add.), pp 43-65) HAZARDS SUMMARY REPORT ON INTERNAL SUPERHEATER CRITICAL EXPERIMENTS. Addendum III. Dates, L. R.; Juliano, J. O.; Kelber, C. N.; Plumlee, K. E. (Argonne National Lab., Ill.).

Descriptions of the fuel assembly and BORAX-V type fuel elements for the internal superheater critical experiments are presented. Hazards analyses include: normal operation excess reactivity with a maximum ramp rate of reactivity of 0.03%/sec; operation errors of 0.1%/sec by using the axial safety rod for control purposes; malfunction of operating equipment such as: fast-fill valve stuck in open position for H_2O fill, control-rod drive switch failure for full withdrawal speed, and failure of interlocks and scram circuits; and failure of void containment in superheater. (D.C.C.)

3890 (CONF-670640–1) MTR REFLECTOR GRAPHITE AFTER 13 OPERATING YEARS. Fast, E.; Cohen, S.; Wheeler, G. V. (Idaho Nuclear Corp., Idaho Falls). [nd]. Contract AT(10-1)-1230. 22p. Dep. CFSTI.

From 8th Biennial Conference on Carbon, Buffalo, N. Y.

The stored energy releasable at low temperatures in the MTR graphite reflector is approaching saturation and does not appear to present a serious risk to continued operation for any credible operational failure. The approach to any condition that conceivably would initiate a spontaneous energy release is sufficiently gradual that adequate corrective measures can be taken. The buildup of radiation damage is consistent with that expected from the operating temperature and measured fast flux. Good agreement is found with previous work to which the present measurements can be compared. The maximum temperature reached in spontaneous release would still be several hundred degrees centigrade below ignition point. Slow oxidation was measured with statistical significance. The temperature and fast neutron flux levels as well are much lower than that at which weight loss rate has previously been measured. (auth)

3891 (GEAP–5164) A PRELIMINARY SEMI-EMPIRICAL APPROACH FOR ESTIMATING VESSEL MOTION ARISING FROM A NUCLEAR EXCURSION. Colmar, R. J. (General Electric Co., Sunnyvale, Calif. Advanced Products Operation). Mar. 1966. Contract AT(04-3)-189. 41p. Dep. CFSTI.

A simplified semi-empirical rationale is developed for the EVESR system to estimate the extent of the potential vessel motion resulting from a serious nuclear excursion. A water-piston is postulated to occur within the vessel as was evidenced in the SL-1 accident. Based on evaluations of the SL-1 incident as well as test data from simulated nuclear excursions at SPERT and Stanford Research Institute, the kinetic energy developed in the water-piston was taken to be 2% of the total nuclear energy released. Consistent with this energy, pressure histories internal to the vessel were synthesized and followed the form observed in underwater deflagrations as a general model. These empirical effects were then incorporated into an analytical procedure which mathematically describes the forces developed interior to the vessel. This detailed description of the internal forces permits the introduction of a suitable analytical model of the external forces from which a potential vessel motion may be estimated. A limiting case of zero external restraint in the upward direction is calculated for a hypothetical nuclear excursion in the EVESR system. The calculated jump does not include several significant effects which are described qualitatively, therefore, it is regarded as an upper bound. (auth)

3892 (IAEA–3498-20) PROGRESS REPORT OF NORA PROJECT, JULY 1–SEPTEMBER 30, 1967. (Institutt for Atomenergi, Kjeller (Norway)). Oct. 1967. Contract 104/R3/US. 25p. (NC–94). Dep. CFSTI.

Topics discussed include: description of mixed steel water reflector; reactivity effects of the steel rods; reactivity measurements for boron steel "grey" control elements; and spectrum index measurements for the "grey" control elements. (D.C.C.)

3893 (MIT–2344-10) USE OF EXPERIMENTS ON A SINGLE FUEL ELEMENT TO DETERMINE THE NUCLEAR PARAMETERS OF REACTOR LATTICES. Pilat, Edward E.; Driscoll, M. J.; Kaplan, I.; Thompson, T. J. (Massachusetts Inst. of Tech., Cambridge. Dept. of Nuclear Engineering). Feb.

1967. Contract AT(30-1)-2344. 182p. (MITNE-81). Dep. CFSTI.

The nuclear parameters of a reactor lattice may be determined by critical experiments on that lattice, by theoretical calculations in which only cross sections are used as input, or by methods which combine theory and experiment. Of those methods which combine theory and experiment, the Single Element Method, abbreviated SEM, is shown to have great usefulness. As used here, the method combines experiments on the smallest meaningful unit of fuel—a single fuel element—with a theory which relates the behavior of a lattice of such elements to the experimentally determined behavior of the single element. Several parameters which characterize a reactor lattice often depend strongly, and in a complicated manner, on the properties of individual fuel elements, but only depend weakly, or in a simple manner, on interactions between the fuel elements. In the Single Element Method, the largest contribution to these parameters is determined by measurements on a single fuel element; only a relatively small correction to account for the presence of the rest of the fuel elements need be estimated theoretically. The determination of lattice parameters by SEM represents a desirable saving of time, money, effort, and material over their determination in critical or exponential experiments. It is shown that the method provides an excellent way of correlating the results of experimental measurements, since it shows what pertinent variables must be used to express the quantity of interest in a linear, or nearly linear, fashion. Values obtained by the SEM for the thermal utilization of lattices of uranium rods in heavy water are compared with THERMØS calculations. Values of ρ_{28}, δ_{28}, and C* are obtained by the SEM for the same lattices. In addition, the theoretical development of the SEM predicts that ρ_{28}, δ_{28}, C*, and δ_{25} should vary nearly linearly with the inverse of the unit cell volume. This explains the experimentally observed behavior and provides an important tool for the rational correlation of experimental results. (auth)

3894 (ORNL-TM-1961) ON-LINE CALIBRATION OF HFIR CONTROL RODS USING THE ROD OSCILLATION TECHNIQUE. Fry, D. N. (Oak Ridge National Lab., Tenn.). Sept. 13, 1967. Contract W-7405-eng-26. 17p. Dep. CFSTI.

The digital computer at the HFIR will need accurate control rod calibration data to perform reactivity balance calculations. An evaluation of the rod oscillation method of measuring differential control rod worth is given. The oscillation method is especially attractive for on-line calibrations, because the measurement does not interrupt the normal operation of the reactor or alter the steady-state power level and, furthermore, it is relatively fast. The accuracy of rod worth obtained using the oscillation method was determined by comparing the results with rod bump-period measurements. The rod worths obtained using the two methods agreed to within 2%. Measurement of differential rod worth at one rod position required 20 sec using the oscillation method and approximately 2 min using the rod bump technique. Therefore, the rod oscillation method should provide accurate and fast on-line control rod calibration data for reactivity balance calculations at the HFIR. (auth)

3895 (ORNL-TM-2033) OAK RIDGE RESEARCH REACTOR QUARTERLY REPORT, APRIL-JUNE 1967. Tabor, W. H.; Hurt III, S. S. (Oak Ridge National Lab., Tenn.). Oct. 11, 1967. Contract W-7405-eng-26. 49p. Dep. CFSTI.

Operating maintenance, instrument and process maintenance, and experiment activities for April-June 1967 are tabulated. Shim-rod calibration tests are discussed; differential and integral rod-worth curves are shown. Profile measurements of lattice housing regions were made to check for structural bowing; results are presented graphically. (M.L.S.)

3896 (RFP-1033) CRITICAL MASSES OF STEEL-MODERATED, ENRICHED URANIUM METAL ASSEMBLIES WITH COMPOSITE STEEL-OIL REFLECTORS. Coonfield, Donald C.; Tuck, Grover; Clark, Harold E.; Ernst, Bruce B. (Dow Chemical Co., Golden, Colo. Rocky Flats Div.). Nov. 7, 1967. Contract AT(29-1)-1106. 13p. Dep. CFSTI.

Critical masses have been determined, experimentally and calculated, for enriched U metal spherical assemblies, moderated internally with a sphere of mild steel of radius 8.01 centimeters. The assemblies were reflected with various thicknesses of mild steel followed by an effectively infinite amount of oil. An irregularity was noted in the graph of the experimental and calculated critical masses as a function of reflector steel thickness. (auth)

3897 (RISO-M-627) DYNAMIKUNDERSOEGELSE AF DEN ELEKTROMAGNETISKE KOBLING MELLEM MAGNET OF ABSORBER I DEN PLANLAGTE HURTIGUDLOESENDE SIKKERHEDSSTANG TIL DR 3. (Investigation of the Dynamic Characteristics of the Electromagnetic Coupling between Magnet and Absorber in a Fast-Releasing Safety Rod Planned for DR 3). Nielsen, Dan S. (Danish Atomic Energy Commission, Risoe. Research Establishment). Sept. 1967. 30p. (In Danish). (R-18-67). Dep.

An analog model of the electromagnet for the planned fast-releasing safety rod for DR 3 was used for investigating the dynamics in the electromagnetic coupling upon interruption of the magnet current. Emphasis was placed on investigating the way in which air gap and eddy currents influence the magnet release time and the first part of the dropping curve of the absorber. Theoretical results are compared with measurements on an actual magnet. (auth)

3898 (RT/FI-(67)22) MISURE DI REATTIVITA SUL R.O.S.P.O. CON TECNICHE PULSATE E STATISTICHE. (Pulsed and Static Reactivity Measurements on the ROSPO Reactor). Pacilio, N.; Ferrari, T. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). 1967. 70p. (In Italian). Dep.

A detailed description is given of reactivity measurements in the ROSPO reactor. The reactivity coefficients of control rods, moderator level, core temperature and measuring apparatus have been employing several different techniques, as pulsed neutron source, neutron statistics, inverse multiplication and stable period. The mutual consistency among the results is widely discussed. (auth)

3899 (RT/ING-(66)27) RAPPORTO DI SICUREZZA DEL REATTORE RB1. (Report on the RB1 Reactor Safety System). Casali, F.; Zappellini, G. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). 1966. 118p. (In Italian). Dep.

A safety report on the RB-1 reactor is presented. The location of the reactor and the physical and demographic characteristics of the zone are described. The design of the reactor building is given. A technical description is given of the nuclear installation itself. An analytical study is made on possible incidents and the health physics precautions are outlined. The standards for protection against fire are discussed. (J.S.R.)

3900 (RT/ING-(67)10) EXECUTION PROCESS FOR THE THROUGH CHANNEL RELATIVE TO THE PROGRAM FOR POWER INCREASE OF THE 1 MW TRIGA REACTOR. Florita, G. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). 1967. 51p. Dep.

The construction of a tangential through channel for low γ intensity experiments in the 1MW Triga reactor is presented. (D.C.C.)

3901 (SRRC-19/67) A MEASUREMENT OF THE TRANSFER FUNCTION OF THE UTR-100 REACTOR USING A REACTIVITY OSCILLATOR. Dickson, J.; Scobie, J. (Scottish Research Reactor Centre, East Kilbride (Scotland)). Aug. 1967. 21p. Dep.

Measurement of reactivity perturbations in the VTR-100 using a reactivity oscillator is detailed. The reactivity oscillator and its associated instrumentation are described. An analysis of results is presented. $1/\beta$ calculations are shown graphically. (M.L.S.)

3902 (TID-24101) INVESTIGATION OF A DIRECT METHOD FOR MEASURING THE RESONANCE ESCAPE PROBABILITY IN THORIUM-WATER LATTICES. Stam, Ephraim (Virginia Polytechnic Inst., Blacksburg. Dept. of Physics). Dec. 1965. 67p. Dep. CFSTI.

Thesis.

A direct method for measuring the resonance escape probability, p, in Th-water lattices was experimentally examined. The system under investigation consisted of a square, close packed, lattice of hollow Al clad Th metal slugs in water, spaced to give a water to Th ratio of 2 to 1 by volume (water to metal 1.45 to 1). A substitute lattice, in which the Th was replaced by lead, was also used to give the same scattering properties as Th but no resonance capture. The neutron source consisted of a fission plate made of a disc of U-235 mounted at the end of a Cd-covered Al tube which conducted a beam of neutrons from inside the thermal column of the VPI reactor into the lattice. Cd-covered In foils were used to measure flux traverses in two perpendicular directions, parallel to the slugs and perpendicular to the slugs. The curves of Ar^2 vs r, where A is the normalized relative activation of the foils, corrected for activation by epithermal neutrons from the reactor, were integrated to infinity and the ratio of the integrals in the Th and Pb lattices yielded p. It was found that $p_\perp$ and $p_\parallel$ differed by only one percent, which was within the experimental error. It was therefore concluded that there was no anisotropy in the resonance absorption. Age to In resonance energy was also obtained. 25 references. (auth)

3903 (TID-24121) EFFECTIVE RESONANCE INTEGRALS IN HETEROGENEOUS MEDIA CONTAINING ABSORBERS IN THE FORM OF PARTICLES. Technical Report No. 326-P/A 9-1. Final Report. Lewis, Richard A. (Stanford Univ., Calif. Nu-

clear Technology Lab.). Sept. 1964. Contract AT(04-3)-326. 122p. Dep. CFSTI.

The adequacy of Nordheim's theory is determined by comparing the results of accurate calculations using his technique with a series of measurements spanning a wide range of absorber volume fractions and diluent types. Nordheim's theory was derived for absorber volume fractions very small compared to one. In the experiment to measure the resonance integral of a homogeneously mixed absorber and diluent material, particles of approximately 20 μ diameter were used for the measurement. Spherical Au particles of volume fractions from 0.001 to 0.30 were used with diluents of Pb and graphite. (D.C.C.)

3904 (ORNL-tr-1522) PLANNING AND PERFORMANCE OF A SHIELDING MOCKUP EXPERIMENT IN THE LARGE IRRADIATION CHANNEL IN THE GEESTHACHT RESEARCH REACTOR (FRG). Schultz, H. (Technische Hochschule, Hanover (West Germany)). Translated for Oak Ridge National Lab., Tenn., from report ABS-THH-1017. 72p. Dep. mn. CFSTI $3.00 cy, $0.65 mn. JCL $7.60 fs, $2.36 mf.

The design of a shielding mockup experiment in the Geesthacht research reactor (FRG) is discussed. Irradiation programs are outlined. Technical problems with design are discussed; construction problems are outlined. Results of the fast, thermal, and epithermal neutron measurements are presented. Gamma flux and dose rate experiments are discussed. A complete energy spectrum of neutron flux profiles is shown graphically. Transverse and longitudinal gamma dose distributions are given for the facility. 15 references. (M.L.S.)

3905 THE 1 MW RC-1 REACTOR OF THE CASACCIA NUCLEAR CENTER: GENERAL CHARACTERISTICS AND RESEARCH PROGRAMS. di Palo, L.; Focaccia, G.; Lo Prato, E.; Marsili, F.; Paoletti, A.; Perni, M.; Prosperi, D.; Sciuti, S.; Verri, A. (CSN, Rome). Energ. Nucl. (Milan), 14: 659-64 (Nov. 1967). (In Italian).

The main improvements to the RC-1 reactor of the Casaccia Nuclear Center which increase its power from 100 kW to 1 MW are described. Some improvements to the experimental channels and irradiation facilities, most of which are brought about by future research requirements are discussed. The research programmes of Solid State Physics, Nuclear Physics, Reactor Physics and Engineering, Radiobiology, to be carried out at the reactor, are briefly described. (13 references) (auth)

3906 D.M.T.R.: A SURVEY OF PROGRESS. Lunning, W. H. (United Kingdom Atomic Energy Authority, Dounreay, Scotland). Reactor, 6: 15-20(Sept. 1967).

The history of operation and development of the reactor is reviewed. Successive development of four designs of fuel element has enabled the power to be increased from 10 to 22.5 MW(t), with a corresponding increase in available neutron flux. The incorporation of neutron convertors to provide high fast flux irradiation is described. (UK)

3907 DETERMINATION OF NEUTRON MULTIPLICATION. II. EXPERIMENTS AND ANALYSIS. Sumita, Kenji; Kaneko, Yoshihiko (Japan Atomic Energy Research Inst., Tokyo). J. Nucl. Sci. Technol. (Tokyo), 4: 491-502(Oct. 1967).

The purpose of the present work is to confirm experimentally that the prompt neutron decay constant of fundamental mode, α_{000}, satisfies the following two requirements from the concept proposed: to be uniquely measurable free from space dependence and detector specification, and to be calculable from the Boltzmann equation. To prove this, a series of pulsed experiments was made at various subcritical states in a reflected graphite-moderated 20% enriched fuel system (SHE). The experimental results confirmed that α_{000} was obtained as a common and unique value at any point of both core and reflector, determined by separation of spatial harmonics, using bare and Cd-covered BF_3 counters. The state of SHE was changed by attenuating the core, with or without central control rod, and by adding distributed poison to the core and/or to the reflector. Direct comparison was made between the experimental results and the calculated values from multigroup treatment using P_1 and S_4 approximation. Calculated values of α_{000} for subcritical states with attenuated core, with or without control rod, showed fairly good agreement with the measured values. In addition, the time-dependent spectral changes of the subcritical systems were also investigated in the experiments. 19 references. (auth)

3908 MEASUREMENTS OF THE NEUTRON SLOWING DOWN TIMES IN FINITE GRAPHITE SYSTEMS BY THE RESONANCE FILTER METHOD. Takahashi, Akito; Sumita, Kenji (Osaka Univ.). J. Nucl. Sci. Technol. (Tokyo), 4: 503-11(Oct. 1967).

Slowing down times were measured in graphite systems by the resonance filter method. The distribution of the slowing down time from 14 MeV to a few energy points from thermal equilibrium was obtained in the form of differences of time response between compensation-filter covered and resonance-filter covered BF_3 counters. From the time distributions thus determined the most probable slowing down time t_{max} and the average slowing down time $\langle t \rangle$ were derived, which were compared with the theoretical values which were calculated with the use of various scattering kernels. The effects of finite medium and space dependence were also evaluated. 16 references. (auth)

3909 NOISE ANALYSIS ON ZERO-POWER-REACTOR SUR 100 BE. Moritz, U.; Vierke, H.; Wesser, U.; Wolf, L.; Zeisset, W. (Univ., Berlin). Atomkernenergie, 12: 415-19 (1967). (In German).

Results of noise analysis of a zero power reactor SUR 100 BE are given. It is shown that a continuous control of a power reactor seems to be possible. (auth)

3910 RESEARCH REACTORS AND THEIR UTILIZATION. Ramanna, R. (Atomic Energy Establishment, Trombay, India). Trans. Bose Res. Inst. (Calcutta), 28: 35-52(June 1965).

A general survey of research reactor types is given. The Indian-owned Apsara and CIR are described. Use of research reactors for basic physics measurements, and a comparison of this use with X-rays is discussed. (M.L.S.)

3911 NEUTRON FLUX IN THE VVR-S REACTOR AFTER SHUTDOWN. Lobanov, E. M.; Yankovskii, A. V.; Sultankhodzhaeva, M. At. Energ. (USSR), 23: 145-6(1967). (In Russian).

The residual neutron flux of the WWR-S reactor was measured in the beam holes a long time after shutdown. In foils were used as activation detectors. Flux measurements made over an extended period are discussed; results are described. The dependence of the residual neutron flux on the burnup level of the fuel elements is established. (TSS)

3912 THERMOELASTIC DYNAMICS OF A PULSE REACTOR. Burgreen, David (Polytechnic Inst. of Brooklyn). Nucl. Sci. Eng., 30: 317-27(1967).

A study is made of the dynamic interaction between the bolts and fuel segments in a pulse reactor assembly which undergoes rapid heating. The analysis of the propagating thermoelastic stress waves in the bolted assembly indicates that the maximum dynamic stresses in the bolts can be many times greater than the static thermal stress. A comparison of the results obtained in the continuum analysis with those from an approximate stereomechanical (spring-mass) model indicates that the latter model gives good results for moderately large ratios of segment mass-to-bolt mass. Analytical expressions are derived which give the peak dynamic bolt stresses. (auth)

3913 OPPORTUNITIES OFFERED BY INTENSE NEUTRON FLUX FOR EXPERIMENTAL TRANSMISSION AND FISSION. Fraysse, Georges (EURATOM, Ispra, Italy). Ind. At., 11: No. 9-10, 71-84(1967). (In French).

Comparisons of the performances of various types of intense neutron sources which are already available or planned, such as: high flux reactors and pulsed reactors, linear accelerators and boosters, super-accelerators are presented. An analysis is made of the criteria which guide the physicist in applying the most suitable experiments to each type of source. Future possibilities arising from present tendencies are discussed. (auth)

3914 THE POOL PILES OF THE GRENOBLE CENTER FOR NUCLEAR STUDIES. Rossillon, Francois (CEN, Grenoble, France). Ind. At., 11: No. 9-10, 51-7(1967). (In French).

The development of pool type piles between 1950 and 1967 has led to a very marked improvement in performances involving only minor extra complications. Hence the interest of these piles is to be found not only in their flexibility and their ease of operation, but also in the large quantity of radiations they provide at a low cost. There has likewise been a great development of the treatments that samples under study can be subjected to in the pile. Thus, the unit composed of the research pile and the radiation devices has reached a sort of maturity which now makes intensive utilization possible for basic research and for technological tests. (auth)

3915 IMPROVEMENTS RELATING TO NUCLEAR REACTOR OF THE POOL TYPE. (to Societe Grenobloise d'Etudes et d'Applications Hydrauliques (SOGREAH)). French Patent 1,366,230. June 1, 1964. Filed May 22, 1963.

The core of the reactor is disposed in a conventional pool filled with a volume of water, and carried by a grid, the lower portion of

which forms the termination of the intake cowling of the cooling circuit. The cooling flow is drawn from the pool by a pump through the supporting grid and passes into a deactivation sump and a heat exchanger, to be reintroduced into the pool through an annular opening which distributes the flow along the periphery. By using a screen, the cooling flow introduced into the pool is drawn into the core in the downward direction, without rising into the protective sheet of water above the screen. The screen is made of a transparent material (Perspex) in order to assure good visibility inside the pool, and in its central portion has an aperture the cross section of which is slightly larger than that of the supporting grid, so that it does not impede access to the core. (IIB)

3916 DEVICE FOR OPERATING A MOVABLE TROLLEY. (to Commissariat a l'Energie Atomique). French Patent 1,352,985. Jan. 13, 1964. Filed Jan. 10, 1963.

Installation for the operation of a trolley which is adapted to move on an irradiation loop away from the core of a swimming pool reactor or to move it nearer to the core. The installation consists of a main drive mechanism which serves to displace the trolley in two opposite directions and of an auxiliary drive mechanism which is synchronized under normal conditions with the main drive mechanism. The auxiliary drive mechanism serves to displace the trolley independently of the main drive mechanism. A coupling is disposed between the trolley and the main drive mechanism. When the coupling is released the auxiliary drive mechanism is set into operation. (IIB)

3917 NUCLEAR REACTOR. Trbojevich, Nikola J. U. S. Patent 3,349,002. Mar. 28, 1958.

A reactor comprising a cylindrical core rotatable about an axis, an outer stationary member tangential of the core and two fissionable and subcritical masses respectively affixed to the core and member is described. The first mass tangentially bypasses the second mass in its proximity, the combined masses become momentarily hypercritical and momentarily generate a divergent fission chain reaction. The mass in the outer member comprises a slide and means for bodily moving the mass in the slide in a direction perpendicular to the axis, for the purpose of adjustment. (auth)

3918 IMPROVEMENTS RELATING TO NUCLEAR REACTORS OF THE POOL TYPE. (to Societe Grenobloise d'Etudes et d'Applications Hydrauliques (SOGREAH)). French Patent 1,364,645. May 19, 1964. Filed May 4, 1963.

The core of the reactor is disposed in a conventional pool filled with water. The cooling water is introduced in the top part of the core through distribution boxes, each of them comprising a grid having orifices, the section of which widens from the top toward the lower part of the grid. The desired direction is imparted to the jet by means of shutters issuing from the distribution boxes. The circulation thus arranged renders it possible to cause the flow of cooling water to circulate from top to bottom, while preventing any penetration by this highly active water into the water of the pool. (IIB)

3919 CAISSON FOR A NUCLEAR REACTOR. (to Commissariat a l'Energie Atomique). French Patent 1,381,532. Feb. 11, 1964. Filed Oct. 30, 1963.

A caisson surrounds the core of a pool type nuclear reactor and is made of a metallic wall provided with longitudinal and parallel bores each of them having an inlet and an outlet for a coolant. Rods of approximately the same cross section are disposed in the center of the bores in order to reduce the flow of the coolant to a thin film. External structure rods are provided in order to fix the caisson on the structure elements of the reactor. (IIB)

3920 IMPROVEMENTS RELATING TO NUCLEAR REACTORS OF THE POOL TYPE. (to Societe Grenobloise d'Etudes et d'Applications Hydrauliques (SOGREAH)). French Patent 1,364,645. July 12, 1965. Filed Mar. 13, 1964.

Instead of introducing the coolant flow into the top of the caisson of a pool type reactor, and drawing it off, through the bottom of the caisson, after passage through the core, it is possible to establish reversed circulation. The cooling flow may be introduced through the bottom aperture of the caisson and discharged through the top. In order to create such a reversing flow, shutters of the inverted V-section are added and the height of the distribution boxes is increased. In such a manner a vortex-ring with descending flow is created in the top of the caisson, resulting in barring the upward passage of the flow coming from the core. (IIB)

3921 IMPROVEMENT RELATING TO NUCLEAR REACTORS OF THE POOL TYPE. (to Societe Grenobloise d'Etudes et d'Applications Hydrauliques (SOGREAH)). French Patent 1,366,843. June 8, 1964. Filed May 21, 1963.

The core of the reactor is carried by a grid and placed in a caisson open at its upper part and having an aperture in the base. The caisson itself is disposed within a conventional pool filled with a volume of water. The cooling flow is drawn from the pool by a pump through the supporting grid and the base aperture and passes into a deactivation tank and a heat exchanger to be reintroduced at the periphery of the pool by means of an annular opening. The reintroduced flow is guided by shutters in such a manner that intake into the core occurs in the downwards direction without any fraction of this flow being entrained upwards towards the uncovered surface of the pool. Thus, a protective layer of water is established close to this uncovered surface. The caisson has a greater cross section than that of the core so as to form an annular space for elements on which tests are to be made. (IIB)

3922 SWIMMING-POOL REACTOR. (to Commissariat a l'Energie Atomique). French Patent 1,363,933. May 11, 1964. Filed Mar. 16, 1963.

The water of the reactor is separated by a partition wall into a bottom compartment containing the core and a top compartment. A circulation system withdraws a flow of water from the bottom compartment, so as to cause the greater part of the flow to pass through a heat exchanger in order to be cooled and then returned into the bottom compartment. Another circulation system comprises means for deactivating the other part of the flow and returning it into the top compartment. The partition wall is provided vertically above the fuel assemblies with sealing members for closing off an integral number of openings providing passageways for the fuel assemblies which is a fraction of the total number of the assemblies. Leakages through the barrier, which is formed by the sealing members, is compensated by the relatively decontaminated flow of water which is returned into the top compartment. (IIB)

3923 POOL TYPE REACTOR. (to Commissariat a l'Energie Atomique). French Patent 1,381,531. Nov. 2, 1964. Filed Oct. 30, 1963.

In order to increase the power of a pool reactor, circulating means are provided. The core of the reactor is directly accessible from the top of the pool. Water serving as moderator and coolant can circulate between an intake and an outlet zone. The circulating means are provided immediately above the intake zone, while deflecting organs disposed in the outlet zone direct the warm and active water coming from the core, towards apertures made in a cylinder, which surrounds the core of the reactor inside the pool. The intake water ducts are disposed in the upper part of the cylinder to provide a descendant circulation between the upper surface of the pool and central part of the cylinder. (IIB)

Production Reactors

Refer to abstract 2588.

Reactor Theory, Components, Fuels and Accessories

Refer also to abstracts 2286, 2316, 2319, 2321, 2370, 2446, 2471, 2560, 2601, 2609, 2612, 2671, 2697, 2709, 2713, 3156, 3158, 3585, 3586, 3641, 3690, and 3706.

3924 (AECL–2775) EFFECTIVE SURFACE AREA OF FUEL CLUSTERS FOR RESONANCE INTEGRAL CALCULATIONS. Halsall, M. J. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). Aug. 1967. 31p. Dep. CFSTI. CAN $1.00.

Measured resonance integrals and initial conversion ratios show a systematic dependence on coolant material which is not reproduced in LATREP calculations. Numerical factors affecting the calculation of the effective surface have been derived which to a large extent remove this discrepancy between measurement and calculation. These factors depend only on the coolant material. Normally resonance integrals for cluster fuel elements are defined only for the whole cluster. A method of apportioning this resonance integral among the various fuel rings in the cluster is described. For air and heavy water coolants the agreement with Hellstrand's measurements of resonance integrals is within the quoted experimental error. However, measurements with H_2O coolant seem to be low. Comparison of these calculation methods with measurements of initial conversion ratio in ZED-2 are more difficult. However, the comparison presented suggests that the calculated effective resonance integrals should be reduced by about 1 barn for all geometries and coolants. The calculation methods presented are straightforward and could be incorporated in the LATREP code without difficulty. (auth)

3925 (AEEW-R–498) THE WINFRITH DSN PROGRAMME, MARK 2. Green, C. (Atomic Energy Establishment, Winfrith (England)). Sept. 1967. 51p. Dep. CFSTI. UK 8s. 0d.

The program solves the multigroup discrete S_n approximation to the Boltzmann neutron transport equation and is written in FORTRAN for the KDF 9 computer. It is considerably faster, and now includes plane and spherical geometries, in addition to the cylindrical geometry originally allowed; an option permitting adjoint or anisotropic problems to be solved is given. A further program, WSN, based on the Carlson discrete S_n method has been written and is also reported. (UK)

3926 (AEEW-R-531) MAGOG: A THREE DIMENSIONAL, TWO GROUP DIFFUSION CODE WITH BURNUP. Hopkins, D.; Oakes, D. B. (Atomic Energy Establishment, Winfrith (England)). Sept. 1967. 43p. Dep. CFSTI. UK 7s. 0d.

MAGOG is a three-dimensional, two-group diffusion code written in E2 FORTRAN for the KDF9 computer and in S2 FORTRAN for STRETCH. It was written to solve problems encountered in the design of Steam Generating Heavy Water Reactors, and it is a member of the PATRIARCH scheme of nuclear–thermal–hydraulic codes. Burnup is simulated through the use of a library of nuclear data generated by the METHUSELAH cell burnup code. The flux solution in each neutron group is obtained using a finite difference expansion allied to a source iteration technique, acceleration procedures being used to speed up the solution. A point rating distribution generated from the flux solution is used to advance each irradiation value independently. A channel power map is then evaluated from the rating distribution. Zero flux or zero flux gradient boundary conditions are included to permit the representation of whole cores or sub-units. The boundary conditions are imposed in accordance with three geometric options: supercell, quarter core, or whole core. Three reactivity control options and an automatic fuel changing routine are included in the code. (UK)

3927 (EIR-124) AUSBAU EINES DEFEKTEN BRENNSTOFFELEMENTES AUS DEM KREISLAUF KASIMIR. (Disassembly of a Defective Fuel Element from the KASIMIR Cycle). Francioni, W.; Moser, P.; Schenker, E.; Suter, F. (Eidgenoessisches Institut fuer Reaktorforschung, Wuerenlingen (Switzerland)). July 1967. 118p. (In German). Dep.

The disassembly of a slightly damaged fuel element from the KASIMIR He cycle, which is built into the DIORIT reactor, is described. The element was removed, together with the in-pile portion of the circuit, from the irradiation channel of the reactor and carried to the hot laboratory for study. The disassembly methods used and the considerations which led to the selection of the various methods are described in detail. The results obtained are also reported. (J.S.R.)

3928 (FEI-68) SOVREMENNYE NAPRAVLENIYA ISSLEDOVANII ZASHCHIT YADERNYKH REAKTOROV. (Modern Trends in the Study of Shielding of Nuclear Reactors). Tsypin, S. G. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Obninsk. Fiziko-Energeticheskii Institut). 1966. 29p. (In Russian). Dep.

A series of new trends in the experimental study of the shielding of reactors is examined. The need for providing a shield of small weight and dimensions, the availability of modern detectors with spectral and selective sensitivity, and the new devices for studying shields initiated the studies which include: the procurement of detailed data; the obtaining of special shield macroconstants; the investigation of shields of limited dimensions; the investigation of heterogeneities in the shield; and the study of the optimum shield with respect to form and composition. (tr-auth)

3929 (GEAP-5355) BURNUP: A FORTRAN IV CODE FOR COMPUTING U AND Pu FUEL BURNUP FROM U, Pu, AND Nd MASS SPECTROMETRIC MEASUREMENTS. Rider, B. F.; Ruiz, C. P.; Peterson, J. P. Jr.; McLaughlin, T. V.; Smith, F. R. (General Electric Co., Pleasanton, Calif. Nuclear Technology Dept.). Oct. 31, 1967. Contract AT(04-3)-189. 103p. Dep. CFSTI.

Heavy element isotopic analysis is correlated with fission product Nd, U, and Pu concentrations in an irradiated U fuel for calculation of burnup (atom percent fission and MWd/MT). Certain reactor parameters including effective neutron absorption cross sections for all U and Pu isotopes, capture-to-fission ratios for U-235, Pu-239 and Pu-241, a two-group description of the neutron spectrum, the average neutron temperature, the reactor fast fission factor, and the distribution of the sources of fission among the fissionable nuclides are computed from the experimental measurements. A description of the method, the equations used, and instructions for use of the code are included. (auth)

3930 (GEAP-5408) DESIGN AND FABRICATION OF EVESR MARK V FUEL BUNDLES. Morris, C. E. (General Electric Co., San Jose, Calif. Advanced Products Operation). May 1967. Contract AT(04-3)-189. 99p. Dep. CFSTI.

The design and fabrication results of the EVESR Mark V fuel and bundle development program are described in this report. Four fuel bundles were designed to incorporate and test certain improvements over the previous seven-rod cluster designs which would be applicable for use in large superheat reactors. Features incorporated in Mark V include ribbed cladding turbulence promoters, lateral-type fuel rod spacers, thin thermal liners, and bimetallic process tube joints. The superheat fuel rods have various thicknesses of Incoloy and Inconel cladding over pellets or compacted powder fuel. Thermal-hydraulic analyses are presented which indicate the proposed fuel performance in EVESR through peak specific powers of 50 kW/kg of UO_2. Fabrication of fuel and bundle components was terminated short of final assembly into four bundles. However, many of the components, including fuel rods and subassemblies, were nearly completed for two of the bundles. (auth)

3931 (NP-16987) ESTUDIO DE PREINVERSION: CENTRAL NUCLEAR PARA LA ZONA DEL GRAN BUENOS AIRES–LITORAL. VII. ANEXOS AL CAPITULO 7. ANEXO 7B. COSTO DEL CICLO DE COMBUSTIBLE NUCLEAR. ANEXO 7C. COSTO DE FABRICACION DE LOS ELEMENTOS COMBUSTIBLES. ANEXO 7D. TRANSPORTE DE COMBUSTIBLE IRRADIADO. (Preliminary Investment Studies: Nuclear Power Plants of the Buenos Aires Region and Coastal Zone. VII. Appendix to Chapter 7. 7B. Nuclear Fuel Cycle Costs. 7C. Cost of Fabrication of Fuel Elements. 7D. Transportation of Irradiated Fuel). (Comision Nacional de Energia Atomica, Buenos Aires (Argentina)). 1965. 94p. (In Spanish). Dep.

The fuel cycle costs for GCR, HWR, PWR, and BWR reactors of 300 and 500 Mw were evaluated. The methods of calculation were outlined. The cost for the fabrication of fuel elements for these four reactor types is calculated. The type of fuel element used, the basis of the calculation, and an analysis of the fabrication costs are presented. The transportation of irradiated fuel elements is then discussed. The containers for transport are described. The precautions taken during the transportation are outlined. The loading, unloading, and decontamination operations of irradiated fuel element are outlined. The transportation costs are evaluated. (J.S.R.)

3932 (TID-24099) INVESTIGATION OF THE CRITICAL PROBLEM FOR A SLAB WITH ANISOTROPIC SCATTERING. Rhodes, Edgar Austin (Virginia Polytechnic Inst., Blacksburg. Dept. of Physics). June 1965. 48p. Dep. CFSTI.

Thesis.

The exact critical problem solution for a bare infinite slab reactor consisting of a homogeneous, isotropic multiplying medium is obtained under the assumption that the angular flux in the slab is described by a one-velocity neutron transport equation whose scattering function is a finite expansion of Legendre polynomials. This solution is obtained by transforming the integrodifferential form of the transport equation into a singular integral equation for the angular flux. An analysis of this equation yields a set of linear constraints which lead to the criticality condition. In addition, an investigation is made of the relation between the above approach and Case's normal mode expansion method used in solving the same problem. Critical half-thicknesses are calculated for several representative multiplying media in the specific case of linear anisotropic scattering. 11 references. (auth)

3933 (TID-24100) PULSED NEUTRON MEASUREMENTS OF THE DIFFUSION PARAMETERS OF HEAVY AND LIGHT WATER MIXTURES AT SEVERAL TEMPERATURES. Salaita, George Nicola (Virginia Polytechnic Inst., Blacksburg. Dept. of Physics). Oct. 1965. 53p. Dep. CFSTI.

Thesis.

Thermal neutron diffusion parameters of 0, 20, 50, 80, and 100 percent D_2O in mixtures of light and heavy water were measured by the pulsed neutron technique at room temperature, near the freezing point of the mixture in the liquid state, and at –20°C in the solid state. A 250-kv pulsed Cockcroft–Walton accelerator, using neutrons from the $_1H^2(d,n)_2He^3$ reaction, was used to generate fast neutrons bursts. The values of the infinite medium decay constant, λ_0, were computed by a least squares fit of λ versus B^2 data. The parameters D_0, C, and λ_{tr} were determined. The resulting values of D_0, C, λ, and λ_{tr} at several temperatures are tabulated. 53 references. (auth)

3934 (UJV-1836) PROSTOROVE A ENERGETICKE ROZLOZENI TEPELNYCH NEUTRONU VE VALCOVE BUNCE HETEROGENNIHO REAKTORU. (Space and Energy Distribution of Thermal Neutrons in a Cylindrical Heterogeneous Reactor Cell). Hron, M. (Ceskoslovenska Akademie Ved, Rez. Ustav Jaderneho Vyzkumu). Aug. 1967. 9p. (In Czech). Dep.

The method for calculation of space and energy spectrum of thermal neutrons is extended to cylindrical geometry using a

suitable approximation for calculation of the first flight collision probability. Results for heavy water cells with three types of fuel elements are mentioned. (auth)

3935 (WCAP-3677-5) FRACTURE MECHANICS EVALUATION OF REACTOR VESSEL STEELS. Quarterly Progress Report for the Period Ending September 30, 1967. (Westinghouse Electric Corp., Pittsburgh, Pa. Atomic Power Div.). Oct. 1967. Contract AT(30-1)-3677. 22p. (EURAEC-1924). Dep. CFSTI.

Work Performed under United States-Euratom Joint Research and Development Program.

Irradiation conditions in the B and W Test Reactor for radiation damage studies on reactor vessel materials are given. Tensile, Charpy V-notch, and drop weight testing of the reactor vessel steels are discussed. Drop weight and tensile testing results are given. Results of Wedge Open Loading (WOL) tests are tabulated. (M.L.S.)

3936 (ZJE-9-67) STEEL PRESSURE VESSELS FOR NUCLEAR REACTORS. Stepanek, St. (SKODA Works, Pilsen (Czechoslovakia)). [1966]. 20p. Dep.

The development, design, production, and operation of steel pressure vessels are discussed. Cylindrical pressure vessels with diameters 8 m and with 90 bars pressure are feasible. (J.C.W.)

3937 TWO-TIME DOUBLET BOLTZMANN EQUATION IN REACTOR KINETICS AND ITS APPLICATIONS. Taji, Yukichi (Japan Atomic Energy Research Inst., Tokyo). J. Nucl. Sci. Technol. (Tokyo), 4: 518-27(Oct. 1967).

A "one collision operator" is introduced, which expresses the macroscopic-stochastic existence of neutrons in a multiplying system. Using this "one collision operator," the one-time doublet Boltzmann equation is extended in the form of a two-time doublet Boltzmann equation. As an application of the two-time doublet Boltzmann equation, we discuss a method of analyzing the neutron fluctuations in a simple reactor model. In the Rossi-α experiment in the one point model with an infinitely small detector, the amplitude of the main correlation term is reduced in magnitude by half as compared to the corresponding term derived by Orndoff. An additional correlation term that decays faster than the main term is derived. The minimum width for a detector to disturb the neutron fluctuation is discussed. (auth)

3938 APPLICATION OF THE NATURAL MODE APPROXIMATION TO SPACE-TIME REACTOR PROBLEMS. Foulke, Larry R.; Gyftopoulos, Elias P. (Massachusetts Inst. of Tech., Cambridge). Nucl. Sci. Eng., 30: 419-35(1967).

A space-dependent reactor kinetics approximation, called the Natural Mode Approximation (NMA), has been applied to the calculation and interpretation of reactor dynamic experiments. The NMA is based on a modal expansion technique where the space- and time-dependent reactor variables are approximated by a series of products of time-dependent coefficients and space-dependent expansion modes. The modes are the eigenvectors of a linear operator derived from the complete set of equations describing the reactor system at an initial reference condition. A pair of computer codes, MUDMO-II and SYNSIG, are used to synthesize approximate modes in two-dimensional systems without feedback. An oscillation test is proposed which may be used to verify key parameters of the NMA. The experimental technique is described and applied to both numerical and actual measurements. In addition, it is shown how a natural mode expansion may be used to interpret standard dynamic experiments when the observations are functions of space and time. The results of calculations of kinetic problems are compared with those of independent calculations which are considered to be exact. Good agreement is established. It is shown that the flux tilting following a localized perturbation is a sensitive function of the relative magnitudes of the measurable parameters of the NMA. The novel idea of "correction modes" is introduced which increases the accuracy of a low-order NMA without appreciable increase in computation time. 19 references. (auth)

3939 THIRD FORATOM CONGRESS. SESSION II. FUEL FABRICATION AND REPROCESSING. Ball, J. G. (Imperial Coll. of Science and Tech., London). Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), No. 66, 21-8(July-Aug. 1967). (In French).

The studies made in Belgium, France, Germany, Italy, and the United Kingdom on the fabrication and reprocessing of fuel elements for fast reactors are briefly outlined. The fuel element selected for fast reactors is an oxide form. The research plan for the development of other types of fuel elements are summarized. The fabrication of the oxide fuels is described with an indication of the control of the radiation and toxicity and of the possible development of automatic installation. The compatibility of the fuel and the isotopic composition is considered. The present capacity for the reprocessing of fast reactor fuels is discussed and future expansion projects are described. The cost and time of the reprocessing are indicated. New techniques for the reprocessing emphasize the decontamination factor and the cost. Some dry reprocessing procedures are briefly indicated. (J.S.R.)

3940 SINUSOIDAL ANALYSIS OF A LOW-POWER NUCLEAR REACTOR BY THE WENTZEL-KRAMERS-BRILLOUIN APPROACH. Tan, Sevim (Middle East Technical Univ., Ankara). Nucl. Sci. Eng., 30: 436-47(1967).

A solution of the zero-power kinetic equations for sinusoidal excess reactivity insertions, previously obtained by the author by Wentzel-Kramers-Brillouin approach (WKB), is further discussed. Explicit equations for the reactor period, reactivity bias, and stabilized reactor response, within the range of applicability of the method, are derived. Harmonic contents of the logarithm of flux for both pure and properly biased sinusoidal reactivity variations are analyzed. Fourier components of flux yielding the new steady-state mean power, the fundamental and the second harmonic are given. Results of the treatment are extended to the describing function of a low-power nuclear reactor and the major error involved in the earlier literature is indicated. The procedure, although developed under the assumption of one average group of delayed neutrons, is expected to yield very satisfactory results even if generalized to multigroup treatment. 15 references. (auth)

3941 REACTOR ANALYSIS BY MONTE CARLO. Rief, H.; Kschwendt, H. (EURATOM-CCR, Ispra, Italy). Nucl. Sci. Eng., 30: 395-418(1967).

A detailed Monte Carlo analysis in one, two, and three dimensions and with different multigroup scattering kernels is presented for a number of actual reactor systems. Several variance reducing sampling techniques are employed. In addition to the prediction of reactivity, much emphasis is placed on generation time calculations with reference to the life cycle. Comparison of the numerical values of reactivity and time eigenvalues with those obtained from the equivalent S_N and j_N calculations was made. The numerical results obtained from different scattering kernels (transport approximation, linear anisotropy, and exact anisotropy) were compared to assessing the influence of these different approximations on the reactivity, absorption, leakage, generation time, etc. Simultaneously, an examination of two different Monte Carlo sampling techniques is presented. To apply a physical test to the method, some highly enriched U spheres, some cylinders of extreme geometry reflected by a variety of materials, and some cylindrical annuli were analyzed and the results compared with experiments. In addition, some systems requiring the full use of the three-dimensional scope of the method are studied. The efficiency of the Monte Carlo procedure is finally illustrated by listing, for several calculations, the probable errors in the reactor eigenvalues and other parameters after 10 min of IBM-7090 computer time. 32 references. (auth)

3942 LINEAR ANALYSIS OF XENON SPATIAL OSCILLATIONS. Stacey, Weston M. Jr. (Knolls Atomic Power Lab., Schenectady, N. Y.). Nucl. Sci. Eng., 30: 453-55(1967).

The methods of linear modal analysis of xenon spatial oscillations are discussed briefly. An extended form of λ-mode analysis, which starts with the linearized neutron, xenon, and iodine balance equations, is presented. This extended λ-mode form accounts explicitly for spatial dependence of thermal flux and utilizes standard diffusion-theory computer codes. (M.L.S.)

3943 PERTURBATION METHOD FOR ANALYSIS OF NEUTRON-SOURCE-WORTH EXPERIMENTS IN NUCLEAR REACTORS. Gandini, A. (CNEN-CSN, Rome). Nucl. Sci. Eng., 30: 451-3(1967).

The derivation of a formulation relevant to linear functionals of the neutron adjoint flux is presented. This formulation is a directly applicable experimental tool which allows correlation of changes in worth of fast neutron sources to systemic changes in the reactor. 6 references. (M.L.S.)

3944 VARIATIONAL FUNCTIONALS FOR SPACE-TIME NEUTRONICS. Stacey, Weston M. Jr. (Knolls Atomic Power Lab., Schenectady, N. Y.). Nucl. Sci. Eng., 30: 448-63(1967).

Two variational principles, which may be used as the basis of modal expansion approximations for treatment of space-time dependence of neutron balance equations for describing reactors, are given. Time-dependent multigroup P_l equations are written in a variational matrix notation; expansion functions which satisfy spatial and temporal boundary conditions are obtained. A time-integrated approximation is then used to obtain equations in spatial notation only. 12 references. (M.L.S.)

3945 HIGHER CAPACITY OF NUCLEAR REACTORS AND DEVELOPMENT OF STEELS FOR PRESSURE VESSELS. Kobayasi, Takesi; Onodera, Sinsaku. Nippon Seiko Giho, No. 20, 28-37(1965). (In Japanese).

Current research and development for increasing the size of the nuclear reactor pressure vessels and steel material required for the increased output are reported. (Rev. Met. Lit.)

3946 CONTENITORE METALLICO PER IMPIANTI NUCLEARI. (Metallic Containment for Nuclear Plants). Cesari, Franco. Rome, Comitato Nazionale Energia Nucleare, 1964. 549p.

The characteristics of metallic containers for nuclear plants are outlined in introductory chapters. The construction characteristics, the design criteria, and design of a container are considered. In the second part the problems of calculation of reactor vessels are examined in detail. The first approximation of the thickness, calculation of the stresses of membranes in the cylindrical bottom and mantle, elastic coefficients, secondary structures, non-static loading conditions, membrane stresses, stresses of thermal origin, verification of the stability of the elastic equilibrium, and superposition of the effects and comparison with permitted stresses are given. Examples are given of the calculations in the last chapter. (J.S.R.)

3947 NUCLEAR REACTOR REACTIVITY CONTROL ARRANGEMENTS. Long, Everett (to English Electric Co., Ltd.). British Patent 1,089,343. Nov. 1, 1967. Filed May 7, 1964.

The design of a control rod placement and drive mechanism for reactor cores with a plurality of fuel channels is presented. The mechanism handles the control rods by means of winding mechanisms with fixed positions in the reactor core, a common drive unit located outside the pressure vessel, and a moveable winding mechanism which connects the fixed rod channels with the drive unit. (D.C.C.)

3948 SOLID MODERATOR STACKING FOR A NUCLEAR REACTOR. (to Commissariat a l'Energie Atomique). French Patent 1,443,326. May 16, 1966. Filed May 12, 1965.

The moderator consists of an assembly of adjacent columns, formed of superimposed prismatic graphite rods. The rods are made of graphite, the thermal coefficient of expansion of which in the direction perpendicular to the axis of extrusion and in the direction parallel to this axis are fixed in such a way that the transverse expansion of the rods in the cold zone of the reactor is reduced to a minimum. The overall longitudinal contraction of the columns may have a minimum absolute value; the longitudinal expansion in the cold zone being partially compensated by the longitudinal contractions in the hot zone. The graphite may be an anisotropic material in which the thermal coefficient of linear expansion in the direction of extrusion is higher than the coefficient of thermal expansion perpendicular to this direction. (IIB)

3949 NUCLEAR REACTOR REACTIVITY CONTROL ARRANGEMENTS. Long, Everrett (to English Electric Co., Ltd.). British Patent 1,089,342. Nov. 1, 1967. Filed May 7, 1964.

The design of reactor control elements and drive mechanism is presented. The drive mechanism handles control rods by means of winding mechanisms with fixed positions in the reactor core, a common drive unit located outside the pressure vessel, and a movable winding mechanism which connects the fixed rod channels with the drive unit. Some of the control elements are made flexible for positioning into the core by the common drive unit. (D.C.C.)

3950 NUCLEAR REACTOR FUELLING ARRANGEMENTS. Long, Everett (to English Eelectric Co., Ltd.). British Patent 1,089,341. Nov. 1, 1967. Filed May 9, 1964.

The design of fuel handling equipment located inside a reactor pressure vessel is presented. The equipment is designed for reactor cores with a plurality of fuel channels and also for reactors with fuel storage facilities inside the pressure vessel. The handling equipment is comprised of multiple fixed guide tubes relating to the core fuel facility, at least one fixed guide tube communicating with the storage facility, and a movable charge chute for transferring fuel elements from the core to the storage facility. A duct is also provided with a pressure-lock to allow fuel transfer from outside the pressure vessel to inside the pressure vessel by using the movable charge chute. (D.C.C.)

3951 IMPROVEMENTS IN VELOCITY LIMITERS. (to General Electric Co.). British Patent 1,090,198. Nov. 8, 1967. Priority date Oct. 23, 1965, United States.

The design of a fluid-activated, velocity-limiting device for positioning and controlling the movement of a reactor control rod on neutron absorber is presented. The velocity-limiting device is comprised of a hollow container filled with a fluid, a control body inside the hollow container, and a fluid passage between the hollow container and control body. The control body moves with a reciprocating motion and uses the fluid passage to restrict motion due to fluid resistance in the hollow container. The control element of the reactor is attached to the control body by means of a piston rod. (D.C.C.)

3952 IMPROVEMENTS IN AND RELATING TO NUCLEAR FUEL ELEMENTS. Boudouresques, Bernard; Maillet, Ennenond; Peice, Jacques (to Commissariat a l'Energie Atomique). British Patent 1,089,168. Nov. 1, 1967. Priority date Mar. 26, 1967, France.

The design of a canned fuel element is presented. The fuel element is tubular shaped with inner and outer cans and coolant flowing both internally and externally. The inner surface has fins extending along the longitudinal axis at 20° angles. The fins are arranged in sectors to form a herringbone pattern. (D.C.C.)

3953 METHOD OF HEATING WORKING MEDIUM IN THE HEAT EXCHANGER OF A NUCLEAR REACTOR INSTALLATION. Kaegi, Jakob (to Sulzer Brothers, Ltd.). U. S. Patent 3,349,003. Aug. 9, 1965. Priority date Aug. 13, 1964, Switzerland.

A variable flow rate, counter current heat exchanger, for use with a nuclear reactor, is described. Parallel secondary coolant flow through the exchanger can be varied in response to temperature changes in the reactor coolant. (J.M.J.)

3954 SAFETY DEVICE FOR A NUCLEAR REACTOR (to Commissariat a l'Energie Atomique). French Patent 1,451,407. July 25, 1966. Filed July 13, 1965.

The reactor is cooled by a liquid which also serves as moderator and comprises a vertical, detachable channel tube of which at least the lower part contains liquid when in place in the reactor. A movable absorber rod is disposed in the channel tube while a control mechanism takes place in the upper part of the channel tube and supports the rod via a detachable coupling. A damping device is integral with the lower part of the channel in order to absorb the kinetic energy of the rod when it falls in the channel. The damping device comprises a hydraulic braking component as well as an elastic mechanical stopping device. (IIB)

3955 HANDLING DEVICE FOR A NUCLEAR REACTOR. (to Commissariat a l'Energie Atomique). French Patent 1,455,218. Sept. 5, 1966. Filed July 13, 1965.

A nuclear reactor loading device is provided with a rotatable cylinder containing ducts in a leak-proof hood. The hood has a vertical channel and can be tightly coupled with the biological shield of the reactor. Means are provided to bring each of the ducts of the cylinder into alignment with the channel wherein a gripping unit is disposed in order to exchange the fuel elements. The hood contains a reception tank with individual reception containers for the elements filled with a stationary liquid. The containers are immersed in another fluid circulating between the tank and a cooling exchanger. The containers are arranged in the tank at the same distance from the axis of rotation as the ducts of the cylinder. The respective number of ducts in the cylinder and in the reception containers in the tank are chosen as a function of the relative numbers of the different elements with respect to the number of channels, so as to reduce as far as possible the dimensional requirements of the necessary biological protection. (IIB)

3956 TEST LOOP. (to Groupement Atomique Alsacienne Atlantique (GAAA)). French Patent 1,452,780. Aug. 8, 1966. Filed July 30, 1965.

The circuit of the loop comprises, incorporated in a leak-proof container, active elements such as a pump and its by-pass, a heater, exchanger-cooler and a flow meter. The container is designed to support the operating pressure and is provided with means of admitting the test fluid as well as a gas under pressure above this fluid. Means are also provided to connect the suction of the pump in the container and its delivery to the external test sections via the heater to the external test sections placed, for example, in the reactor. (IIB)

3957 CORE STRUCTURE FOR A NUCLEAR REACTOR WITH A SOLID MODERATOR. (to Commissariat a l'Energie Atomique). French Patent 1,436,061. Mar. 14, 1966. Filed Mar. 12, 1965.

The central part of the core is made of vertical columns, each being composed of massive rods of equal section of moderator material held in position with respect to each other by keying. The columns define channels for receiving fuel elements which channels are disposed at the top of a regular network. The cross sections of the channels are larger than the greatest section of the columns. The column structure rests on a flat support and is surmounted by a ballast element, which is divided into adjacent parts

separated by clearances, and disposed in a pattern identical with that of the channels. (IIB)

3958 IMPROVEMENTS RELATING TO CONTROL DEVICES FOR PARALLEL TUBULAR NUCLEAR REACTOR ELEMENTS. (to Commissariat a l'Energie Atomique). French Patent 1,448,295. June 27, 1966. Filed June 24, 1965.

The reactor pressure tubes are arranged in a cluster in a regular lattice. The device consists of retractable probes coming into contact with the tubes. The probes are conveyed by a movable carriage fitted with rollers bearing on two adjacent tubular elements. The carriage includes a self-contained control mechanism which controls the physical characteristics of the tubular elements and notably their thermal insulation. The object is to reduce the overall dimensions of such control devices, to improve their movement between the parallel tubes. The control device can be inserted or withdrawn from the reactor during operation or shut-down. (IIB)

3959 NUCLEAR REACTOR FUEL BUNDLE. Lass, James L.; Venier, Dominic A. (to General Electric Co.). U. S. Patent 3,349,004. Jan. 17, 1966.

The rods are arranged in a predetermined geometric array, including at least one removable rod, one tie plate positioned at one end of the fuel bundle and operatively connected to the ends of the rods, and a second tie plate positioned at the other end of the fuel bundle and connected to the other ends of the rods. The first tie plate forms at least one opening to permit removal or insertion of the removable rod, including a slot adjacent to the opening that extends the entire thickness of the first tie plate. The removable rod includes a locking mechanism that cooperates with the opening and slot in the upper tie plate to retain the removable rod in a fixed position. (auth)

3960 SOLID MODERATOR BLOCK FOR A NUCLEAR REACTOR. (to Commissariat a l'Energie Atomique). French Patent 1,436,739. Mar. 21, 1966. Filed Mar 17, 1965.

The moderator rod has, in order to limit the axial and circumferential restraints, a helical slot in its lateral surface, the bottom of which rests on a cylinder coaxial with the rod. The slot may be formed in the interior of the rod, or on the external surface or may be in both simultaneously. The slots may extend along the whole length of the bar or only a part of its length, the bar being suitably of large section. (IIB)

3961 MAGNETIC SWITCHING APPARATUS. Nieuwhof, G. W. E. Canadian Patent 765,045. Aug. 8, 1967.

The design of a device for better reliability for nuclear reactor control than the micro-switch is given. A magnetic reed switch is used by means of a magnet connected to the operating mechanism and moveable inside a shielding tube. When the magnet is inside the shielding tube the reed switch is open and when the magnet protrudes beyond the end of the shielding tube the reed switch contacts will close. A very small movement of the protruding magnet will result in a relatively large change in the magnetic field strength in the location of the reed switch. (F.S.A.)

3962 PRESSURE CONTAINER OF PRESTRESSED CONCRETE FOR A NUCLEAR REACTOR. (to Dyckerhoff and Widmann Kommanditgesellschaft). British Patent 1,088,521. Oct. 25, 1967. Priority date Jan. 15, 1964, Germany.

The design of a pressure container, consisting of prestressed concrete and formed as a hollow cylinder, for reactor shielding is presented. The cylindrical pressure container is made of prefabricated rings of reinforced concrete arranged coaxially above one another. (D.C.C.)

3963 USE OF AGAR-AGAR AS PROTECTION AGAINST RADIO-ACTIVE PRODUCTS. (to Etablissements Lemer and Co.). French Patent 1,385,276. Nov. 30, 1964. Filed Mar. 11, 1964.

Agar-agar is added to the water serving as biological shield against radioactive products in general, and in particular against neutron emissions of nuclear reactors. The addition of agar-agar makes the water gelatinous and even solid, preventing the flow of the water out of any orifice in the container. (IIB)

3964 SAFETY DEVICE FOR PRESSURE TUBE NUCLEAR REACTORS. (to Commissariat a l'Energie Atomique). French Patent 1,449,804. July 11, 1966. Filed July 2, 1965.

The reactor may produce an important release of gas in the case of accident. The installation includes a practically airtight enclosure containing elements of the primary cooling circuit, well collectors and a pipe connecting the enclosure to the atmosphere. The pipe has at least equal volume to that occupied by the gas released in an accident at abnormal pressure. The pipe has a straight flat section and is equipped with guiding piers in order to cool the gas and prevent mixing of the contaminated gas released during the accident with the air normally occupying the pipe. The enclosure consists of a biological shield containing the reactor and the heat exchangers. (IIB)

GENERAL

3965 (BNWL-336) GENERATION AND BLOCKING OF EXPERIMENTAL POINTS FOR FRACTIONAL FACTORIALS. Mahaffey, J. A.; Schlosser, J. E. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Oct. 1967. Contract AT(45-1)-1830. 45p. Dep. CFSTI.

The use of computer programs in designing experiments having factorial treatment arrangements for two, three, and four level designs is explained. The input and output are discussed and illustrated by examples, and a print-out of the programs and subroutines is included. Further possibilities for applications of these programs are suggested. (auth)

3966 (BNWL-390) MAXIMUM LIKELIHOOD NONLINEAR CORRELATED FIELDS (BATTELLE-NORTHWEST PROGRAM LIKELY). Duane, Bernard H. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Sept. 1967. Contract AT(45-1)-1830. 111p. Dep. CFSTI.

Battelle-Northwest program LIKELY constructs maximum likelihood multidimensional vector fields satisfying any statistical-or-deterministic linear-or-nonlinear vector field theory cast as a variational extremal subject to correlated-statistic or implicit-anholonomic constraints. (auth)

3967 (BNWL-573) PLUTONIUM ABSTRACTS. Volume 7, Number 9. Russell, Barbara G. (ed.) (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Sept. 30, 1967. Contract AT(45-1)-1830. 77p. Dep. CFSTI.

References, with abstracts, covering plutonium technology are listed under the following subject headings: biology and medicine, chemistry, health and safety, metallurgy and ceramics, miscellaneous, physics, and reactor technology. (161 references). (M.C.G.)

3968 (COO-1680-3) EXCHANGE OF INTERLAYER CATIONS IN MICACEOUS MINERALS. Progress Report, February 1, 1967-September 30, 1967. Scott, A. Duncan; Smith, S. J. (Iowa State Univ. of Science and Technology, Ames. Dept. of Agronomy). Oct. 23, 1967. Contract AT(11-1)-1680. 9p. Dep. CFSTI.

The following areas of work are described: comparison of interlayer K replacement by various replacing cations (Li, Na, Mg, Ca, Sr, and Ba) in NaTPB extracting solutions; conversion of bulk samples of Na-degraded micaceous minerals to other cationic forms; effect of particle size on the exchange of interlayer K in micas; exchangeability of K in naturally fine-grained micaceous minerals (including soils and soil clays); and developing methodology (including equipment) for the determination of hydration characteristics of degraded micas. It was found that interlayer K exchange can occur in the same mineral particle by two mechanisms, edge or layer weathering, and that the extent to which each mechanism is involved determines if all or only a part of the K is replaceable. Edge weathering, which is predominant in large particles, allows all the K to be exchanged. As the particle size decreases, layer weathering increases and the amount of exchangeable K decreases. This effect of particle size was established with dry-ground micas and soils (with naturally fine-grained micaceous minerals). These results are pertinent to concepts regarding natural weathering of micas and the release of nonexchangeable soil K to plants. (auth)

3969 (EGG-1183-1324) PREDICTING THE SWITCHING CHARACTERISTICS OF ENHANCEMENT METAL-OXIDE-SEMICONDUCTOR TRANSISTORS (MOST'S). Tech Report No. L-844. Virchow, Carl F. (EG and G, Inc., Las Vegas, Nev.). May 1, 1967. Contract AT(29-1)-1183. 164p. Dep. CFSTI.

The device parameters of the Metal-Oxide-Semiconductor transistors (MOST'S) are reviewed, and measured for sample transistors, in order to determine a simple but usable equivalent circuit for switching applications. The selected switching equivalent circuit is mathematically analyzed in the frequency domain, and the resulting, transformed, time domain equations are used, with the aid of a digital computer, to predict the switching characteristics of sample transistors. Comparison of the predicted characteristics with the measured switching waveforms, shows the switching equivalent circuit, and the computational method used, to be accurate and useful. The computer programs developed and written for this study are shown to be of assistance in the selection of MOST's and certain circuit parameters for specific switching circuits and specifications. (auth)

3970 (IDO-12016) GUIDE FOR DETERMINING SPECIFICATIONS IN THE USE OF ACOUSTICAL TILE. Held, Bruce J. (Idaho Operations Office (AEC), Idaho Falls. Health and Safety Div.). June 1960. 28p. Dep. CFSTI.

A guide is presented which gives more satisfactory results than do the specifications which many industries are using. Applications of this guide are illustrated with examples which are common to many industrial plants and business facilities. It is pointed out that tile is not a cure-all and should only be used after the situation has been evaluated and it is found that the noise problem cannot be corrected at the source or isolated. Other types of environmental correction which might be more effective and cheaper should also be investigated. These include such devices as panel absorbers, functional absorbers, and artificial masking techniques for correction of a noise environment. If tile is selected for the correction, spectrum shape, placement and mounting must be considered in order to achieve the maximum correction at the minimum cost. Finally, it is noted that this guide is not intended as a solution to all annoyance noise problems. It is only intended to help obtain more satisfactory usage of money to be spent on acoustical tile. Many noise problems occur which only a trained acoustician can solve satisfactorily. (auth)

3971 (JUL-Bibl.-5(2nd Ed.)) VERZEICHNIS DER BERICHTE DER KERNFORSCHUNGSANLAGE JUELICH DES LANDES NORDRHEIN-WESTFALEN-e.V. Veroeffentlicht in der Zeit von Juli 1960 bis April 1967. (Register of Reports of the Juelich Atomic Research Establishment, July 1960-April 1967). (Kernforschungsanlage, Juelich (West Germany)). June 1967. 81p. (In German). Dep.

A register of 470 reports on nuclear research from the Juelich Atomic Research Establishment from July, 1960 to April, 1967 is presented. (W.H.K.)

3972 (LA-3769) TRANSPARENT, LIGHTWEIGHT SAFETY SHIELDS FOR SMALL-SCALE OPERATIONS INVOLVING EXPLOSIVES. Urizar, Manuel J.; Smith, Louis C. (Los Alamos Scientific Lab., N. Mex.). Aug. 1967. Contract W-7405-eng-36. 8p. Dep. CFSTI.

Laminated glass, polymethyimethacrylate, and polycarbonate (Lexan) safety shields were subjected to blast and fragments from 11.5 gm, steel-confined explosive charges, and to impact by .30 cal bullets. A ¼-in.-thick sheet of glass backed by a ½-in.-thick sheet of Lexan proved to be an especially effective combination under the conditions of these tests and is recommended as a lightweight, transparent safety shield for small-scale operations involving explosives. (auth)

3973 (NP-17017) TENTH ANNUAL REPORT, 1965-1966. (Atomic Energy Commission, Tokyo (Japan)). 110p. Dep.

An administrative report on the activities of the Atomic Energy Commission of Japan is given for the 1965-1966 period. The general areas of development and utilization of reactors, nuclear fuels, application of radiation, safety, environmental radioactivity counter measures, international cooperation, training and education of scientists and engineers, and public relations are covered. An organization chart, a listing of reactors and critical assemblies in Japan, and governmental budgets for fiscal year 1965 and 1966 are presented. (M.L.S.)

3974 (NYO-2902-11) SOMATIC MUTATIONS IN THE MOTH EPHESTIA. Report on Research, August 1, 1964-September 1, 1967. Caspari, Ernst W. (Rochester Univ., N. Y.). Contract AT(30-1)-2902. 46p. Dep. CFSTI.

Progress is reported on studies on the induction of somatic mutations in the moth Ephestia by the injection of 5-bromodeoxyuridine, 5-flurouracil, or DNA from Ephestia during various developmental stages. (C.H.)

3975 (ORNL-TM-1817) RESPONSES OF INFLUENTIALS TO NEGATIVE CONTINGENCIES. Bobrow, Sue Berryman (Oak Ridge National Lab., Tenn.). Nov. 1967. Contract W-7405-eng-26. 51p. Dep. CFSTI.

This report is divided into five sections: (I) Introduction, where we try to give the reader an intuitive understanding of our intellectual questions; (II) Independent and Dependent Variables, where we talk about the parameters of the phenomenon we want to explain; (III) Hypotheses, where we state some of the ideas we now have about why different individuals and groups start at the same point and come out at sometimes the same, sometimes different, points: (IV) Intervening Variables, where we talk about the variables which are involved in the hypotheses and have to be differentiated so we can design measures of them and thus test the relevance and power of our hypotheses; and (V) Theory of Action and Person and Group Differences, where essentially we just refer to, not discuss, work on an analytic

system for talking about what persons and groups do and what kinds of persons and groups they are. (auth)

3976 (ORNL-TM-2007) REMOVAL OF CONSTANT TERMS FROM DO LOOPS. Sullivan, J. G. (Oak Ridge National Lab., Tenn.). Oct. 25, 1967. Contract W-7405-eng-26. 49p. Dep. CFSTI.

Techniques are described which can cause significant decreases in the execution time of Fortran programs. Examples are given which illustrate the techniques. (auth)

3977 (ORNL-TM-2038) STABLE ISOTOPE CUSTOMER LIST AND SUMMARY OF SHIPMENTS, FY 1967. Keith, Susan C. (comp.) (Oak Ridge National Lab., Tenn.). Nov. 1967. Contract W-7405-eng-26. 39p. Dep. CFSTI.

This report is made to aid those concerned with the management of the separation and sales of stable isotopes. The information is divided into two sections. The first section is an alphabetical list of domestic and foreign customers with the stable isotopes purchased during the fiscal year. The second section is a tabulation of the shipments, quantities, and dollars for domestic, foreign, and project categories for each isotope; the total figures for each isotope are also included. The total number of stable-isotope loan shipments and quantities is listed at the end of the tabulation. (auth)

3978 (ORO-2503-8) STRUCTURAL STUDIES OF METAL COORDINATION COMPOUNDS. Progress Report, October 1, 1966–October 1, 1967. Quagliano, James V. (Florida State Univ., Tallahassee. Dept. of Chemistry). Nov. 15, 1967. Contract AT(40-1)-2503. 14p. Dep. CFSTI.

Research on donor properties of positively charged ligands toward metal ions is summarized. Topics covered include: structural studies of $ML^{+}X_2$ complexes; five-coordinated Ni(II), a d^8 system, in C_{3v} symmetry; and complexes of cyclic tertiary amines. (M.C.G.)

3979 (R-67ND8) PRESSURES GENERATED DURING THE FOAMING OF A POLYURETHANE RESIN. Scheid, C. C. (General Electric Co., St. Petersburg, Fla. Pinellas Peninsula Plant). Oct. 27, 1967. Contract AT(29-2)-656. 12p. (GEPP-11). Dep. CFSTI.

During foaming of Lockfoam BX-105-B10, carbon dioxide is generated and can result in component or container damage if pressure is excessive. In a given container assembly, foam pressures are small (only 20 psi maximum) compared to those resulting from temperature cycling during environmental testing. Increases in foam pressure correlate with increases in exothermic temperature rise. Effective reduction in foam pressure is achieved by increasing the number of container vent holes and the container heat transfer rate. The test procedure used to determine generated pressures during Lockfoam foaming and the results of testing are described. (auth)

3980 (SC-CR-67-2540) A STUDY OF IMPACT EFFECTS ON SPHERICAL SHELLS. PART II. A THEORETICAL AND EXPERIMENTAL STUDY OF THE RESPONSE OF SPHERICAL SHELLS TO IMPACT LOADS. Simonis, John C.; Stoneking, Charles E. (Georgia Inst. of Tech., Atlanta. Engineering Experiment Station). Dec. 1966. Contract 48-0521. 284p. Dep. CFSTI.

For Sandia Corp., Albuquerque, N. Mex.

A theoretical and experimental study of the effects of impact on spherical shells was conducted. Spherical shells from .75 to 1.25 inch outside diameter and from .08 to .13 inch wall thickness were fabricated from steel and impacted at 50 to 800 fps into steel targets with the shells at ambient temperature. (auth)

3981 (SC-DC-67-1923) ELASTIC–PLASTIC COLLAPSE OF STRUCTURES SUBJECTED TO A BLAST PULSE. Murfin, Walter B. (Sandia Corp., Albuquerque, N. Mex.). Sept. 1967. Contract AT(29-1)-789. 22p. (CONF-671031-1). Dep. CFSTI.

From 37th Shock and Vibration Symposium, Orlando, Fla.

A finite difference method is used to analyze the elastic–plastic, large deflection response of shell structures under blast loading. It is shown that, although the usual design methods are adequate for some conditions, they may be overconservative under other conditions. When the shell structure is surrounded by an elastic medium, elementary design methods are grossly conservative. (auth)

3982 (SC-DC-67-2313) A METHOD FOR IMPROVING THE LOCATION OF CONNECTING PATHS FOR CIRCUIT CARD WIRING. Bittner, B.; Ulrich, J. (Thomas Bede Foundation, Los Altos, Calif.). Oct. 1967. Contract AT(29-1)-789. 12p. DTIE.

A method was derived for reducing the blocking phenomenon in circuit board wiring by deforming the wiring path and moving it away from obstructions. Coded in FORTRAN and used in ACCEL, practice indicates that the technique is effective in increasing the number of corrections achievable on a single side of a circuit card. (F.S.)

3983 (SC-M-67-607) EVALUATION OF SAMPLES FLOWN ON USAF ROCKET MISSION DURING LEONID SHOWER. Klamerus, Leo J. (Sandia Corp., Albuquerque, N. Mex.). Oct. 1967. Contract AT(29-1)-789. 36p. Dep. CFSTI.

An evaluation is made of several sampling slides and microscopic grids used in an attempt to capture micrometeoritic particles during the great Leonid meteor shower of November 17, 1966. These samplers were aboard the payload of a USAF air-launch air-recovery rocket sent to 318,000 feet from White Sands Missile Range on that day. It is concluded that the majority of the particles observed on the collection surfaces are contamination artifacts. Nine specific recommendations are given to attempt to minimize this problem on future sampling missions. (auth)

3984 (SC-M-67-639) USER'S MANUAL FOR ACCEL SYSTEM. Fisk, Clifford J.; Caskey, David L. (Sandia Corp., Albuquerque, N. Mex.). Oct. 1967. Contract AT(29-1)-789. 119p. Dep. CFSTI.

ACCEL, a set of computer programs designed to aid in construction of electronic printed circuit boards is described. ACCEL has the capability to produce all the design information required by a printed circuit fabrication shop for construction of the boards. Input information is furnished by the circuit designer in the form of a circuit schematic drawing, and information on the parts used in the circuit. This information is then transcribed onto punched cards. The computer output is graphical in the form of several plots. These include a schematic drawing, a parts list, an assembly drawing showing the location of parts on the printed circuit board, a hole-drilling coordinate list, and masks to be used in etching the circuit board layers. Thus, the ACCEL system performs four major tasks. First, it edits the engineers' data, resolves the schematic into a node-component list, looks up physical and electrical data for the parts used in the circuit, and notes any errors in the data. Second, it locates the components on the board by an iterative process. Third, the program lays out the interconnection pattern between the components. Fourth, ACCEL generates the output plots. The use of ACCEL can significantly reduce the time required to produce a finished printed circuit board. (auth)

3985 (SC-RR-67-734) PATRICIA: PRACTICAL ALGORITHM TO RETRIEVE INFORMATION CODED IN ALPHANUMERIC. Morrison, Donald R. (Sandia Corp., Albuquerque, N. Mex.). Oct. 1967. Contract AT(29-1)-789. 34p. Dep. CFSTI.

PATRICIA is an algorithm which provides a flexible means of storing, indexing, and retrieving information in a large file, which is economical of index space and of reindexing time. It does not require rearrangement of text or index as new material is added. It requires a minimum restriction of format of text and of keys; it is extremely flexible in the variety of keys it will respond to. It retrieves information in response to keys furnished by the user with a quantity of computation which has a bound which depends linearly on the length of keys and the number of their proper occurrences and is otherwise independent of the size of the library. It has been implemented in several variations as FORTRAN programs for the CDC-3600, utilizing disk file storage of text. It has been applied to several large information-retrieval problems and will be applied to others. (auth)

3986 (SC-TM-67-795) SINK. Sherman, S. W. (Sandia Corp., Albuquerque, N. Mex.). Oct. 1967. Contract AT(29-1)-789. 18p. Dep. CFSTI.

SINK is a CDC 3600 program written in FORTRAN and COMPASS which translates 3600 FORTRAN (Version 5.2) to Univac FORTRAN V. (auth)

3987 (TID-24122) FORECASTING BOUNDARY LAYER TURBULENCE FROM SYNOPTIC METEOROLOGICAL DATA. Final Report. Stinson, J. Robert; MacCready, Paul B. Jr. (Meteorology Research, Inc., Altadena, Calif.). Sept. 15, 1963. Contract AT(04-3)-458. 71p. (MRI-63-FR-94). Dep. CFSTI.

Continuous wind and temperature data and turbulence (wind vertical angle) tapes are available for heights up to about 1000 ft as a result of a diffusion program conducted in 1961. The data are dominated by the low-level jet situation at nighttime near Dallas. In the present project the turbulence records were processed by sigma meters, and the turbulence and meteorological data were examined with respect to the synoptic situations to establish the feasibility of forecasting, from synoptic data, those turbulence factors which are deemed important for vertical diffusion. For nighttime and the limited terrain and weather

situations studied, reasonable forecasts can apparently be achieved. The appropriate turbulence intensity relates fairly well to height, wind speed, and stability; the nightly evolution of stability and wind speed in the jet can be estimated from the synoptic situation, principally from knowledge of the geostrophic wind. Empirical relationships are noted between turbulence energies at long wavelengths (which dominate the diffusion) and at short wavelengths in the inertial subrange (where some measurement simplifications exist), and these make possible simpler turbulence measuring programs covering a wider variety of terrain and synoptic conditions. (auth)

3988 (UCID-15224) THE PHOTON FILL-TIME OF A FABRY-PEROT SPECTROMETER. Burgess, T. J. (California Univ., Livermore. Lawrence Radiation Lab.). Oct. 31, 1967. Contract W-7405-eng-48. 4p. Dep. CFSTI.

The establishment of the interference structure of the Fabry-Perot transmission spectrometer involves the superposition of multiple partial transmissions. Each partial transmission is delayed in time with respect to the preceding one by an amount equal to twice the photon transit time between the etalons. The spectrometer therefore exhibits a delayed rise-time response to a step function of optical input which is called the photon fill-time. An expression is derived which describes the photon fill-time of the spectrometer. (W.H.K.)

3989 (UCID-15240) DETECTION AND DIAGNOSIS OF MALFUNCTIONS IN ENERGY MANIPULATIONS SYSTEMS. Osborne, Robert Lee (California Univ., Livermore. Lawrence Radiation Lab.). [1966]. Contract W-7405-eng-48. 136p. Dep. CFSTI.

Thesis.

A method is presented for choosing measured variables and generating algorithms which will detect and diagnose system malfunctions to the correct subsystem or environmental cause. The method is applicable to lumped parameter, energy manipulating systems which include linear and a large class of nonlinear systems. Malfunctions involving system structure changes are allowed. On-line operation is assumed. No assumptions relative to system excitation are made. An indication of system condition is made at each data sample time. Intermittent malfunctions in memory systems are treated. For cases where there is additive noise on the measured variables, a method of nonlinear filtering is presented. Malfunction detection is defined as the departure of the measured system state from the acceptable range of system states. This acceptable range of system states is referred to as the system performance specification and is generally a function of time. The characteristics of a good system performance specification relative to malfunction detection are listed in the dissertation and in many cases are found to differ from commonly used design specifications. The complete method is applied to a multiple tank hydraulic system simulated on a digital computer. Malfunctions including component parameter changes and system structure changes are detected and correctly diagnosed. These changes include simultaneously occurring malfunctions in different subsystems as well as intermittent malfunctions. The nonlinear filter operation for malfunction detection is demonstrated on first and second order systems although it is not limited to lower order systems for its application. A step by step procedure is given so that starting from a physical description of the system, the engineer can specify the malfunction detection and diagnosis apparatus and software. (auth)

3990 (UCRL-17438) COMBUSTION OF HEPTANE DROPLETS IN A HOT GAS FLOW. Bert, Joel Lawrence (California Univ., Berkeley. Lawrence Radiation Lab.). Oct. 1967. Contract W-7405-eng-48. 74p. Dep. CFSTI.

Thesis.

Burning rates of individual n-heptane droplets were measured under forced convective conditions and environmental temperatures of 550 to 700°C. The droplets were supported in a hot air stream rising at approximately their terminal velocity and their burning histories were recorded by high-speed motion-picture photography. From analysis of the photographs data on droplet size, convective velocities and burning rates were obtained. The effects of gas temperature, drop size, and convection on droplet burning rate coefficients were studied. In the size range studied, 100 to 500-μ droplet diameter appeared to have no effect on burning rate coefficients. The coefficients were also not noticeably influenced by convection for relative velocities up to 90 cm/sec. These results are in accord with predictions of simplified combustion models. However, the observed rate of increase of burning rate coefficient with increasing temperature between 550 and 700°C was much greater than present combustion theory would predict, but is consistent with the few results of other investigators available for elevated environmental temperatures. These results indicate that additional phenomena influencing burning rates at elevated temperatures and/or convective conditions may have to be considered. (auth)

3991 (UCRL-17739) NUMERICAL SOLUTION OF COUPLED, ORDINARY DIFFERENTIAL EQUATIONS. Newman, John (California Univ., Berkeley. Lawrence Radiation Lab.). Aug. 1967. Contract W-7405-eng-48. 36p. Dep. CFSTI.

A wide variety of problems involving ordinary differential equations can be linearized about a trial solution and then put into finite difference form. The resulting coupled, tridiagonal matrices can be solved readily on a high speed, digital computer, and the nonlinear problem can then be solved by iteration. (auth)

3992 (UCRL-17811) IGNITION OF FUEL DROPLETS IN HOT STAGNANT GASES. Long, Gordon Alfred (California Univ., Berkeley. Lawrence Radiation Lab.). Sept. 1967. Contract W-7405-eng-48. 76p. Dep. CFSTI.

Thesis.

A technique was developed for study of self-ignition of fuel droplets in air that enables measurement of ignition delay and observation of the formation of the initial flamefront under near-stagnant conditions at elevated temperatures and atmospheric pressure. This method involves the very rapid insertion of a hollow filament filled with the fuel to be studied into a furnace that allows precise control of the experimental environment temperature up to 1500°C. Immediately following insertion, a droplet is formed at the filament tip. The ensuing ignition is recorded by a high speed (approximately 1000 frames per second) motion picture camera. This technique was applied to the study of ignition of n-heptane droplets in the temperature range of 500 to 860°C. Ignition delay times from 850 msec to 22 msec were reported, which appear to be generally consistent with values reported by other investigators but somewhat longer than those measured under conditions of forced convection. Initial flamefronts were observed to form in an approximately spherical configuration at a distance from the surface of the droplet and to move outward slightly following formation. (auth)

3993 (UCRL-50328) TIME-RESOLVED EMISSION SPECTRA OF THE DETONATION PRODUCTS OF PETN. Catalano, Edward; Hornig, Howard C. (California Univ., Livermore. Lawrence Radiation Lab.). Oct. 16, 1967. Contract W-7405-eng-48. 8p. Dep. CFSTI.

Time-resolved emission spectra were obtained from detonating pentaerythritol tetranitrate (PETN). Shuttered exposures of 200-nsec duration were taken with a Kerr cell, at times from 0.1 to 3.5 μsec after the detonation front had passed. Several emission lines were obtained, superposed on a very low intensity continuum. Attempts were made to estimate the emissivity of the continuum. (auth)

3994 (ANL-Trans-526) THE DETECTION OF DEFINED REVERSIBLE ASSOCIATIONS ("REVERSIBLE POLYMERISATES") OF ACRIDINE ORANGE BY ABSORPTION AND FLUORESCENCE MEASUREMENTS IN AQUEOUS SOLUTION. Zanker, Valentin. Translated by Elmar K. Wilip (Argonne National Lab., Ill.), from Z. Phys. Chem. (Leipzig), 199: 225-58(1952). 31p. Dep. CFSTI. JCL $3.60 fs, $1.16 mf.

The important dye Acridine Orange was investigated quantitatively in aqueous solution for its spectroscopic behavior in absorption and fluorescence in the entire concentration and pH-range. It was found that during the passage over the pH-range the dye exists in four forms that differ with respect to their inherent color and the color of the fluorescence light. All dissociation constants were determined at 20°C and were found to be equal to $K_{base^{\circ}ion^{+}} = 3.55 \times 10^{-11}$, $K_{ion^{+}\circ ion^{++}} = 4 \times 10^{-1}$ and $K_{ion^{++}\circ ion^{+++}} = 1.4 \times 10^{3}$. The form present in the neutral range is the positive univalent dye cation whose optical behavior is by strongly concentration dependent. The fluorescence-microscopically important phenomenon of the red and green fluorescence was also studied quantitatively and it was found that the Acridine Orange cation forms defined reversible associations that agree in part with the Scheibe polymers and that permit analogies with dyes which dissociate to double ions up to medium dye concentrations (10^{-3} M). The thermodynamic quantities of the dissociation constants, the free dimerization energy, the precipitated heat, and the entropy that are of importance for the dimer formation were calculated from the position of the equilibrium in dependence on the concentration and the temperature from measured optical data. Although no definite statements can be made with respect to the number of members of the higher associations, it is considered to be of the same type as the Scheibe high polymers. The characteristic red fluorescence effect of the concentrated dye solutions originates from an energy mechanism that, although it can be contemplated theoretically, has not been proven to a full extent by earlier measurements in aqueous solutions. (auth)

3995 (ANL-Trans-534) ON THE DEFINITION OF ALGORITHMS. Kolmogorov, A. N.; Uspenskii, V. A. Translated by

Elmar K. Wilip (Argonne National Lab., Ill.), from Usp. Mat. Nauk, 13: No. 4, 3-28(1958). 28p. Dep. CFSTI. JCL $2.60 fs, $1.07 mf.

The mathematical definition of algorithms is presented, and the concept of the algorithm as connected with the concept of partial recursion functions is discussed. An example of an algorithm is presented and discussed. (W.H.K.)

3996 (SC-T-67-0954) ANGULAR MOMENTUM CONSIDERATIONS FOR SATELLITES WITH MOVING INNER MASSES. Schiehlen, W. Translated by Marcel I. Weinreich (Sandia Corp., Albuquerque, N. Mex.), from Z. Angew. Math. Mech., 46: T132-4(1966). 5p. Dep. CFSTI. JCL $1.10 fs, $0.80 mf.

Since the rotary motion of a vehicle in the state of weightlessness can be affected by moving inner parts, it is necessary to consider the motion of internal machine components in space vehicles and satellites. Equations are presented for expressing motions in satellites with several translatory and rotational mass movements. (J.H.M.)